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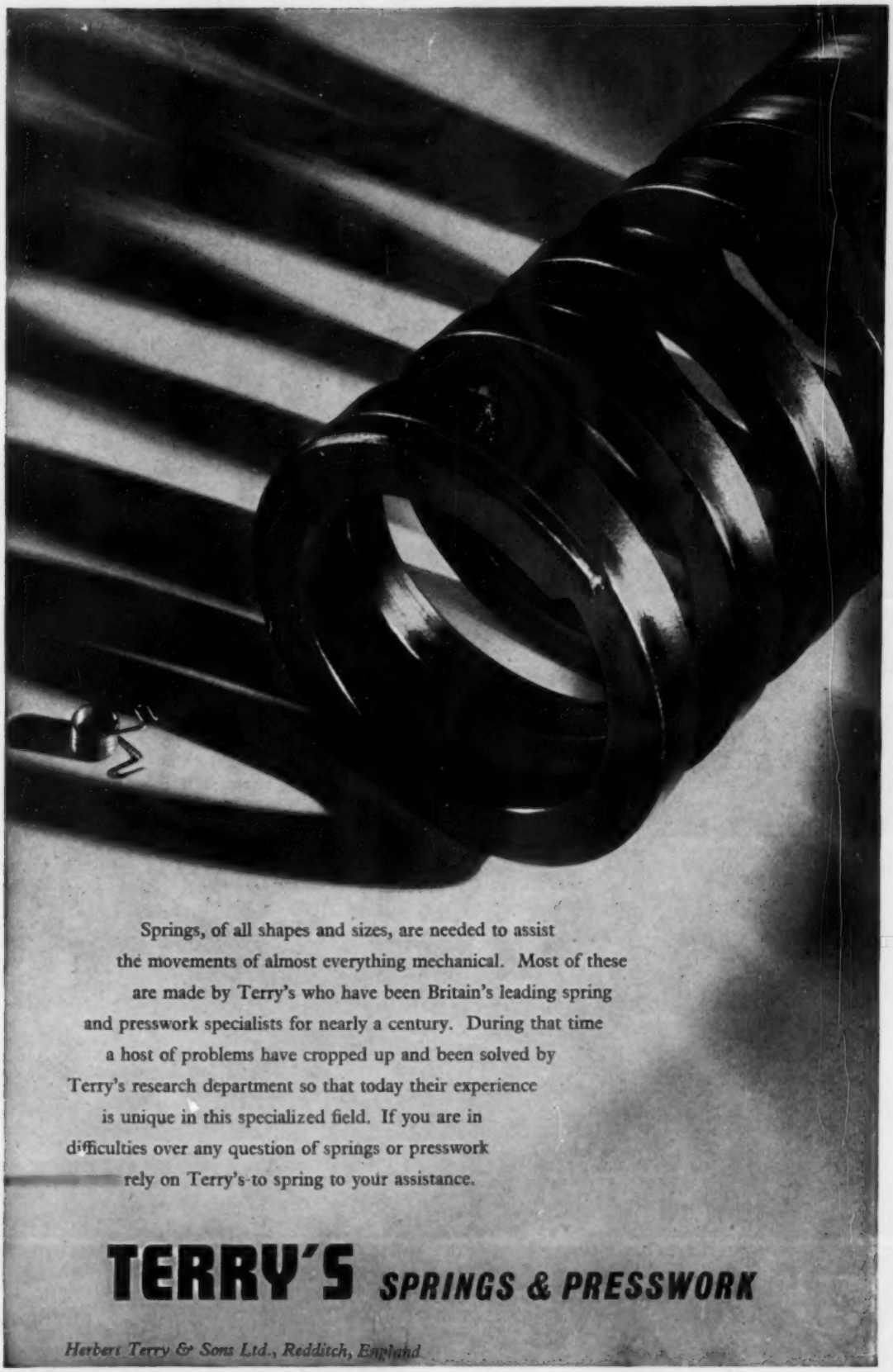
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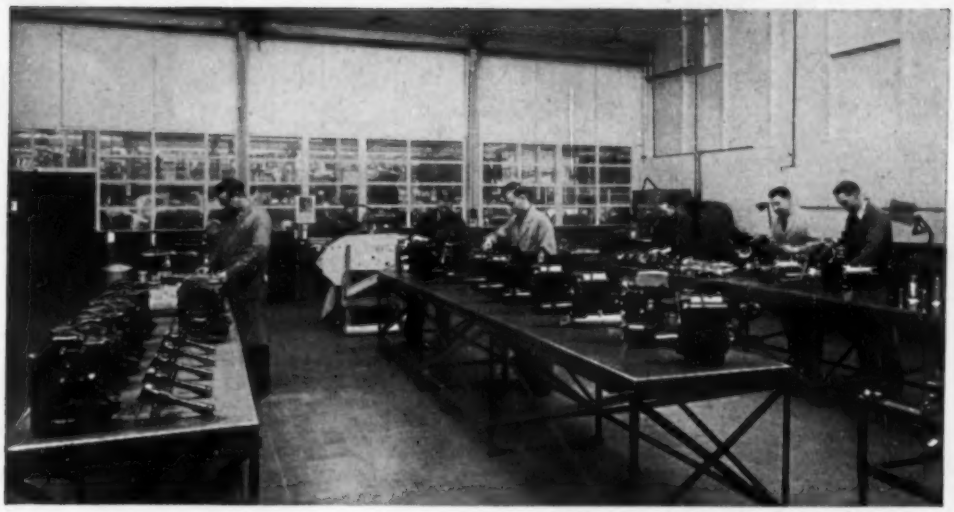

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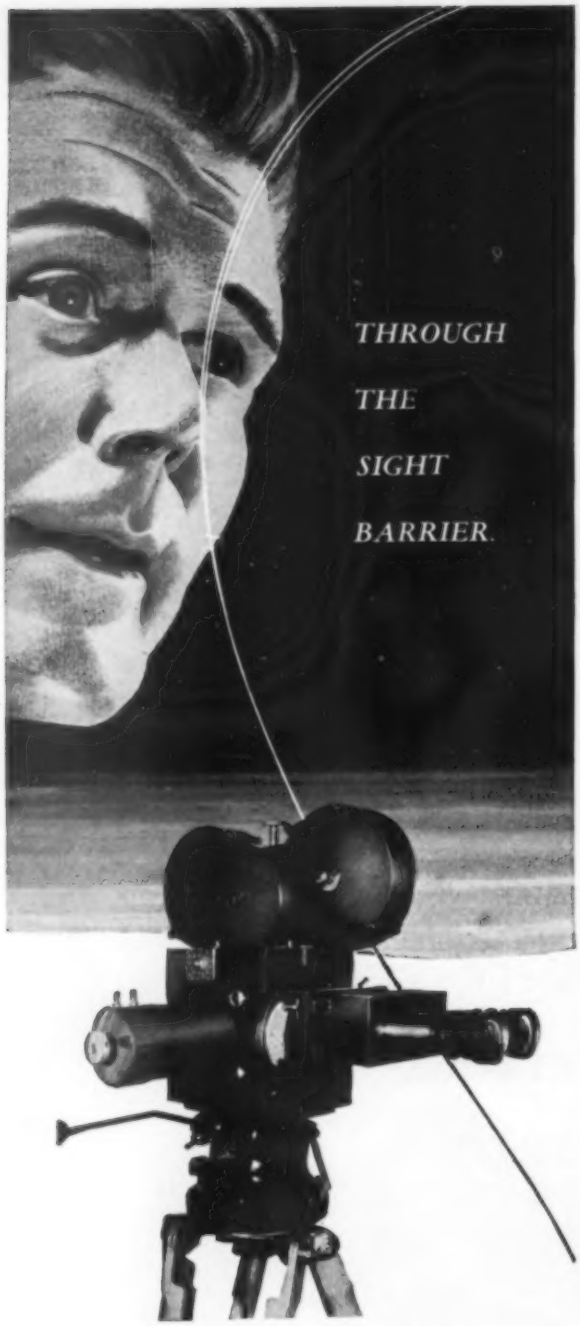

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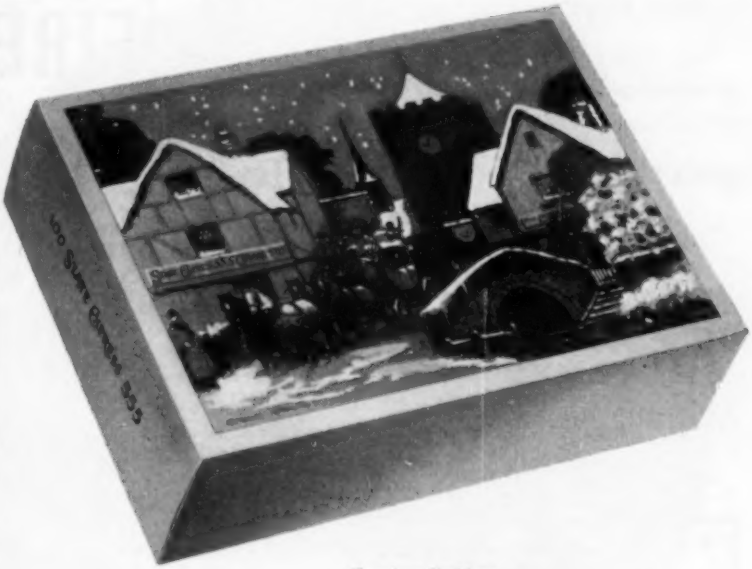

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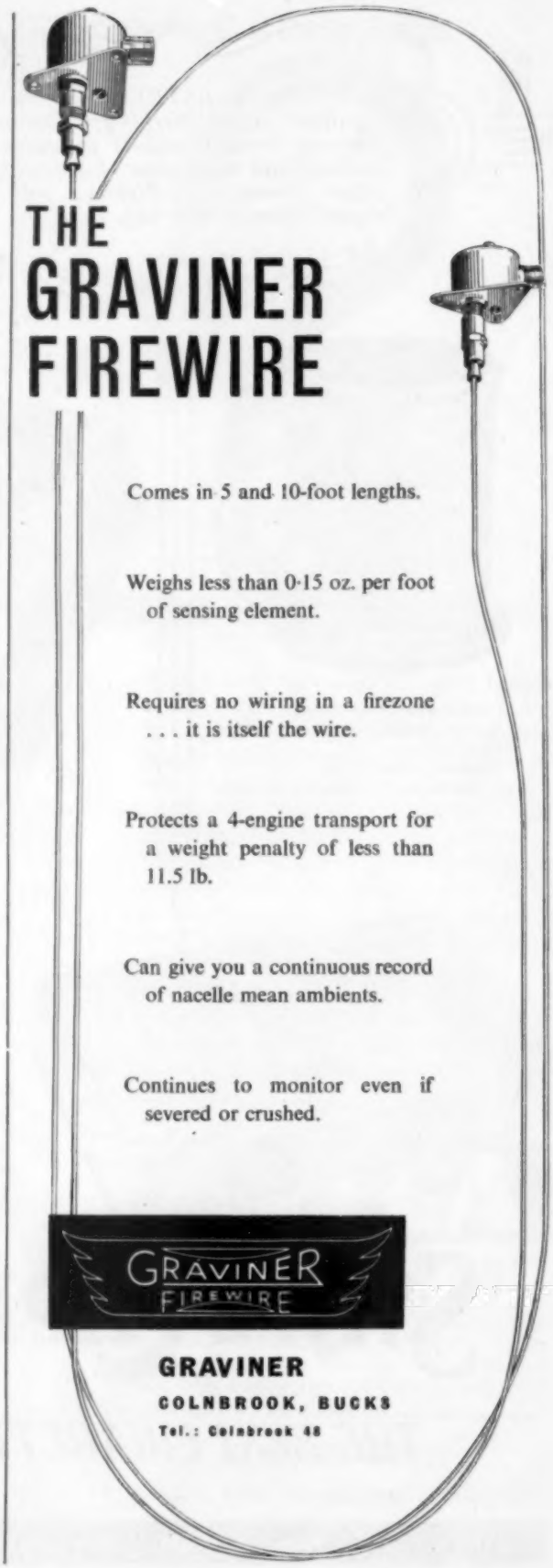

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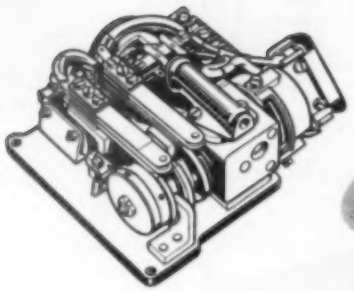

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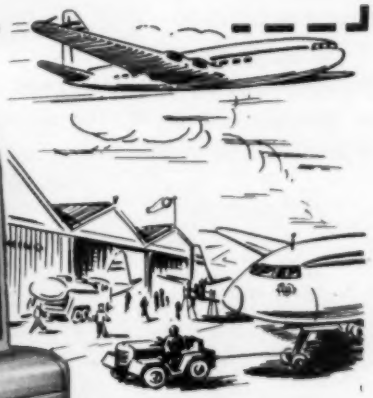

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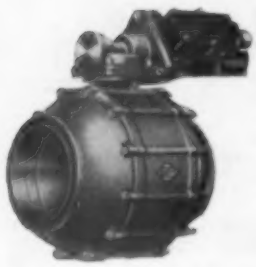

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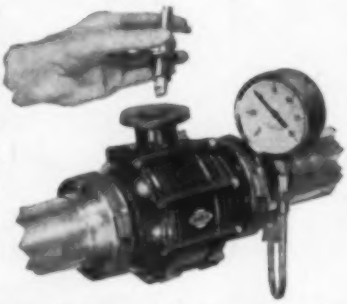

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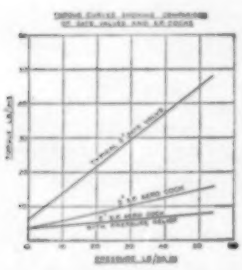

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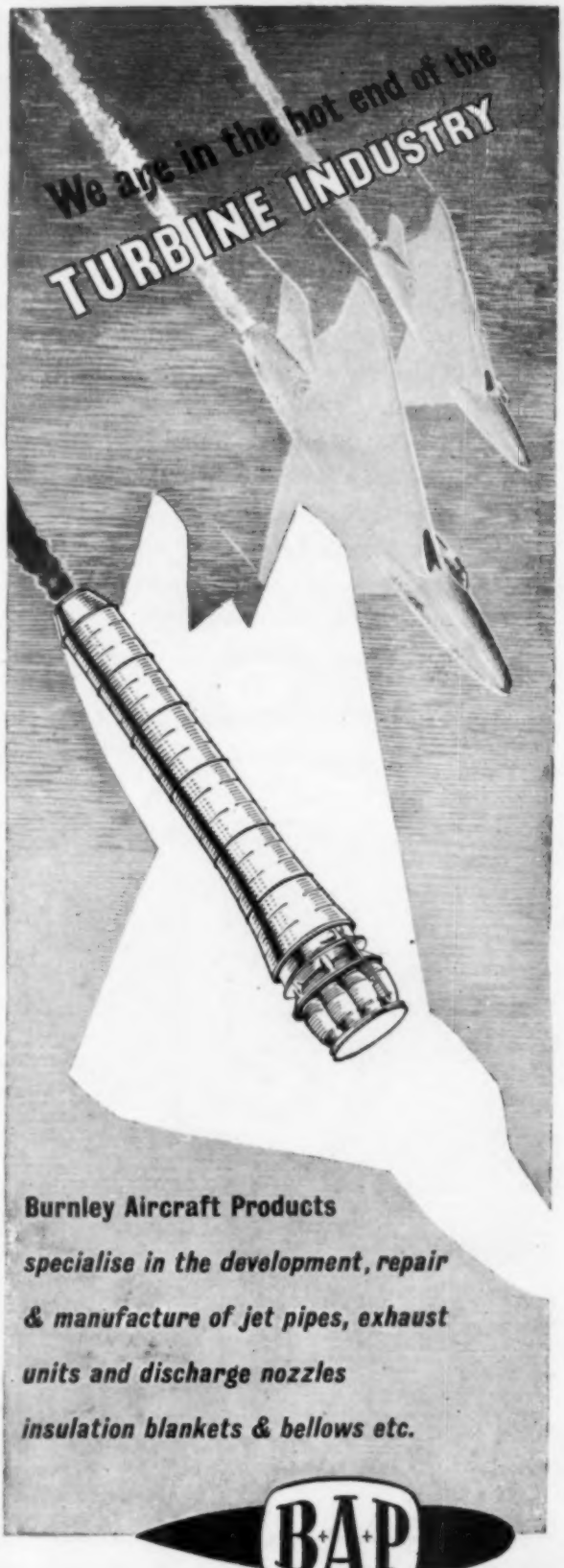

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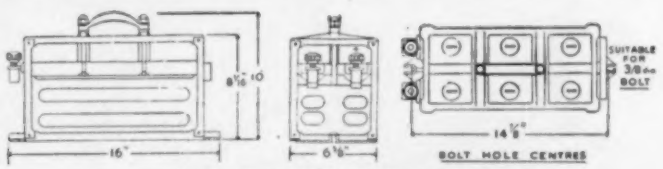

Side and end views of 6-EP19B/2 with battery layout diagram

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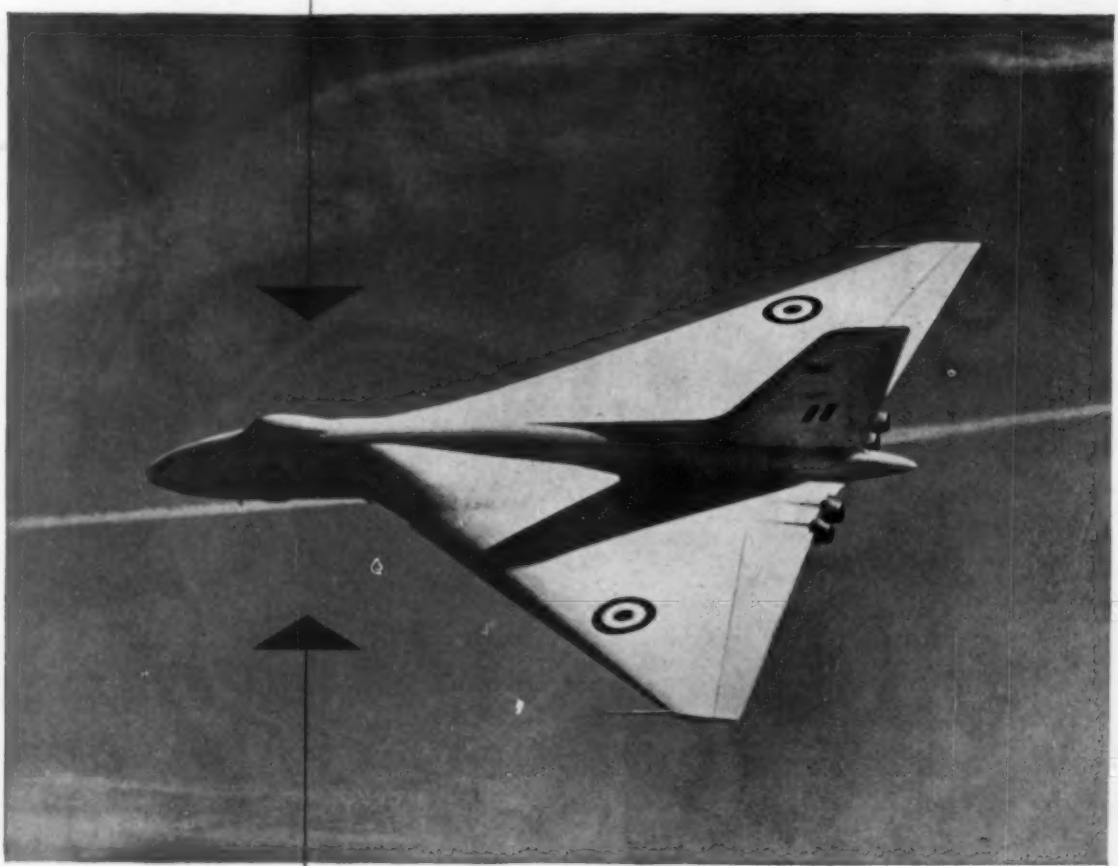

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Sucking and Blowing

POSSIBILITIES inherent in control of the boundary layer and circulation of air around wings have been explored for many years past. Last week we published a summary of a lecture given by a famous German aerodynamicist, Dr. Gustav Lachmann, who has played a prominent part in these studies. Briefly, the suggestions he made were that by sucking away the boundary layer, or alternatively by re-energizing the layer by injecting a high-velocity air jet across the surface concerned, various benefits can be gained. For example, if the system were used to postpone the breakdown of laminar flow, reduction in drag of the order of 75 per cent might be achieved. Alternatively, the airflow could be made to adhere to a trailing-edge flap even at the maximum angle of deflection, greatly improving low-speed qualities. And these advantages could be achieved for quite acceptable penalties in terms of weight and cost.

The study of the whole subject of boundary-layer control has been confined largely to theoretical investigation, to laboratory experiment and to a small number of full-scale trials on aircraft of normal "turbulent" conception.

It is abundantly clear that little further purpose will be served by experimenting with boundary-layer control systems fitted as auxiliary devices and afterthoughts to existing aircraft. What is now needed is a design in which the airframe, power plant and boundary-layer control system are integrated and developed together. It seems certain that if this were done the resulting aircraft would offer performance in advance of anything else in its class. Until such work is instigated and practical results demonstrated those whose job it is to design to military and civil specifications cannot be blamed for tending to regard the subject as of academic interest only. The culmination of the many years of theoretical and experimental work awaits a full-scale research contract.

Although it is, perhaps, too much to expect individual manufacturers at this juncture to stake their reputations on an aircraft in which the whole design is based on control of the boundary layer, it does appear that they could usefully apply a great deal more effort to the many associated problems—such as the production of very accurate airframe components—which must be solved before the laminar aircraft becomes a reality.

Of course, the British manufacturers and the Ministry of Supply are not blind to the possibilities of laminar-flow control, and the fact that information regarding recent experiments is restricted may perhaps be taken as heartening in its implications.

Projected or Launched?

ON consideration we find that we still cling to a quaint old idea that an important part of the experience of an airman should be concerned with the feel of the air. So much of flying today is associated with brute thrust, feel-less and powered controls, and missile-like progression, that by comparison with flying a light aircraft it differs for the man at the controls as would the *Ark Royal* from an International dinghy.

Not so many months ago we understood that, in the absence of experience or unanimous opinion, a number of jet basic trainers were being ordered by the R.A.F. to discover whether all-jet training was the best thing for military pilots. We have not heard of any official change in these plans, nor have any trials as yet been made. But, as an indication of the trend of thought and development, it is clear that in the meantime almost everyone has come to accept it as a foregone conclusion that jet basic training for military pilots will be adopted. (And, incidentally, we see no reason to doubt the wisdom of such a change—but we are not here concerned with that particular consideration.)

The result of this, it seems, may be "lop-sided" pilots, well trained for first-line military duties but less prepared to undertake light-aircraft and civil flying—which many have always chosen, or been required, to do. Fewer and fewer will have felt the air under them, will have sat at the stall, caught a ballooned hold-off with the engine as the aircraft teeters at 20 or 30 feet, or observed drift, sink or skid—surprising movements when flying at speeds little higher than that of the wind. This is pleasure lost and experience missed. It provides one more good reason for advocating gliding as an official recreation for Service pilots and for encouraging the formation of private light-aircraft groups at R.A.F. stations, with facilities available to all ranks.

FROM ALL QUARTERS

EIGHT TAKE SHAPE: In the vast assembly hall at Filton, B.O.A.C.'s first Britannias are progressing in a promising manner. Still short of engines and pressurized flying hours, these aircraft might, it is suggested, be the subject of a new development drive.

CIVIL AVIATION IN THE HOUSE

DOUBTS and fears about the immediate future of the British aircraft industry in the light of recent setbacks represented the main theme of a Debate in the House of Commons last Monday evening, when the two annual reports of the Airways Corporations were considered.

MR. J. B. PROFUMO, Under-Secretary for Civil Aviation, opened with a reference to significant civil-aviation milestones during the past year. There were the Pacific agreements, which would allow a round-the-world partnership of two great Commonwealth airlines (B.O.A.C. and Qantas) and the Strasbourg Conference, when the U.K. successfully pressed important proposals regarding air transport development within Europe.

Overall expansion of air transport was clearly reflected in the work of the A.T.A.C. who, during the year, had dealt with 118 applications, 13 from the Corporations and 104 from independent operators.

As to the Corporations, perhaps the most encouraging feature had been the reduction in operating costs by 6.1 per cent in the case of B.E.A. and 2.9 per cent for B.O.A.C. Another welcome point was the co-operation that clearly existed between the independent operators and B.O.A.C.

After noting that—for the third year running—B.O.A.C. had not asked for any Exchequer grant, Mr. Profumo spoke of B.E.A.'s continuing deficit and future prospects. It might appear paradoxical that, with the introduction of the Viscount and the Elizabethan, and with a general expansion of traffic over all routes, the revenue should have fallen. One of the reasons might have been the indiscriminate introduction of tourist fares which, suggested Mr. Profumo, was misjudged as far as Europe was concerned. He noted with pleasure that at I.A.T.A.'s last conference some of these fares had been increased. It was estimated this would bring an annual revenue-increase of £400,000.

Another special problem was that of the short-haul operator whose costs were certainly higher than those of long-distance operators. On the operation of B.E.A. in general, he noted that the Corporation had never yet bought a new aeroplane from other than the British aircraft industry.

Turning to long-term development, Mr. Profumo said this was closely connected with the development of the helicopter. The problem was two-fold—production of the right type of commercial machine, and the development of "airstops." Introduction of helicopter transport depended primarily upon the goodwill of the city dwellers themselves. In particular, there was the question of noise—the major problem to be overcome.

He assured the House that the Minister would see to it that the introduction of scheduled helicopter services was not delayed by the lack of suitable landing sites. Next spring B.E.A. intended to operate an experimental scheduled service from the South Bank, using the S-55 [picture, p. 753] with floats. The fare would be roughly 30s and four passengers would be carried.

Dealing with the recruitment of aircrew to civil aviation, Mr. Profumo said the Minister was engaged in a close study with the department concerned; an announcement would be made as soon as possible.

The Under-Secretary concluded with references to the Comet accidents, which he agreed "represented a serious setback," adding that grave problems now faced the British aircraft industry.

MR. FRANK BESWICK (Lab., Uxbridge) dealt at some length with the problem of B.E.A.'s growing deficit. He discounted the argument that it could be attributed to amortization charges or to a reduction in passenger rates, which were problems only to be expected with the introduction of new types and the decision to attract more passengers by the reduction in certain fares. One must consider whether it was right to lure people away from the trains and buses by subsidised air tickets. The Minister must make up his mind whether the services provided by B.E.A. were to be primarily commercial, or social services.

There seemed to be an absolutely unanswerable case for special revenue payments to B.E.A. for uneconomic services provided for certain areas, particularly in Scotland.

Mr. Beswick then dealt with the consequences of the Comet setback. B.O.A.C. had put £5 million in the Comet 1 and they would have another £4 million in Comet aircraft which they could not now use. Who was going to bear that loss? A further problem was the £4½ million which had been paid in progress payments for the Comet 2.

Even more important was the problem of the future. Everyone had been talking for years about Britain's lead in civil aircraft and now we had the British national airline operator considering the purchase of American machines, or at any rate, of American airframes. But one must be realistic; in recent years there had been several significant developments—including the report of a recent select committee, the observations of a visiting congressional committee, and other comments—all pointing to production delays in the British aircraft industry.

It was further to be noted that in recent years varying misfortunes had befallen the Tudor, Hermes, Ambassador, Brabazon and Comet.

All this raised the question as to whether our national resources were being deployed to the best advantage and whether it was not now the time for a high-level and independent inquiry into the whole set-up of the industry and its relationship with the Government departments.

Dealing with the Britannia, he suggested it would be possible to do more to bring forward this machine in time to recover ground lost by the Comet setback. Bristols had said that intensive development was proceeding, but he wondered if it was as intensive as, say, the efforts made by Lord Mountbatten and Sir Arnold Hall respectively in recovering and examining the wreckage of the Comets. What Mr. Beswick had in mind was the possibility of quicker and more intensive engine testing and of a much more concentrated flying and development programme than was now contemplated.

SIR ROBERT PERKINS (Con., Stroud and Thornbury) said the Britannia promised to be at least equal in every respect to, and probably superior to, the DC-7D. The Government should set up some such inquiry before any order for the DC-7D was placed.

The proposal to buy these American aircraft when there was a comparable British machine available was a vote of "no confidence" in the British aircraft industry, and it would have a tragic effect on our export trade.

On October 17th the Bristol Aeroplane Co. had received a telegram from an agent in the country where they had good hopes of selling up to ten Britannias to one of the world's major airlines. It read: "Let me make one thing clear from the very start. If B.O.A.C. at this stage decide to order or even to continue negotiations for the DC-7D there is no idea whatsoever

***REMODELLED:** The North American FJ-4 Fury, further reference to which is made on page 736, differs greatly from its naval "FJ" precursors and from the F-86 Sabres of the U.S.A.F. Powered by a Curtiss-Wright J65-W4 (Sapphire) of 7,800 lb thrust, it will serve as an intercepter or as a carrier of special weapons. Features include drooping, inset ailerons.*

to try to sell the Britannia in any shape to our airline, and as far as they go we might as well close the shop."

G/C. C. A. B. WILCOCK (Lab., Derby N.) suggested Britannia development should not be left to just one company, but that work might be contracted out between several. The help of the R.A.F. might also be called in.

W/C. P. B. LUCAS (Con., Brentford and Chiswick) said he found it difficult to believe that Sir Miles Thomas would really court unpopularity in ordering DC-7s unless he felt, on the evidence before him, that it was comparatively necessary.

A. Cdre. A. V. HARVEY (Con., Macclesfield) said he thought Sir Miles Thomas completely wrong in considering the ordering of aircraft that might be delivered in 1958-9.

He understood that B.O.A.C. had made 12 different changes in the specification to the Bristol since 1947. That meant delay. A. Cdre. Harvey went on to speak of the relations between B.O.A.C. and Bristol. He was told that these relations were excellent when the annual report was issued in July. But he suspected that when the Douglas representative was at the Farnborough Show something happened that altered the turn of events. When a Member intervened to complain of this "very serious imputation," he said one knew the Douglas people were over here at the time . . . and undoubtedly saw the Corporation.

MR. J. BOYD-CARPENTER, Minister of Transport and Civil Aviation, replying to the debate, said there were extremely important considerations on either side of the DC-7D problem. There was the need for B.O.A.C. to ensure that it was competitively equipped; and there was a great deal of concern in the industry about the effects of such a step being taken by B.O.A.C. It would be wrong to start committing himself to opinions which he ought not lightly to express at this moment.

Westland 35-seat Westminster

THE Westland company's intention to build a 35-seat helicopter earlier than expected is announced by the chairman, Mr. Eric Mensforth, in a statement accompanying the annual accounts. "Our association with the Sikorsky division of the United Aircraft Corporation," he says, "has enabled us to make proposals to potential users to develop and produce, at an earlier date than otherwise possible, a large twin-engined helicopter. It would have a range of uses, both for passenger carrying, where it would accommodate 35 people, and for Service use, particularly that of the Army, where it would carry a load of five tons. We have in mind to call this helicopter the Westminster."

The aircraft would presumably derive from the S-56, which carries 26 armed troops and in a commercial version would take 35 passengers on ranges of over 200 miles.

New A.R.B. Test Requirements

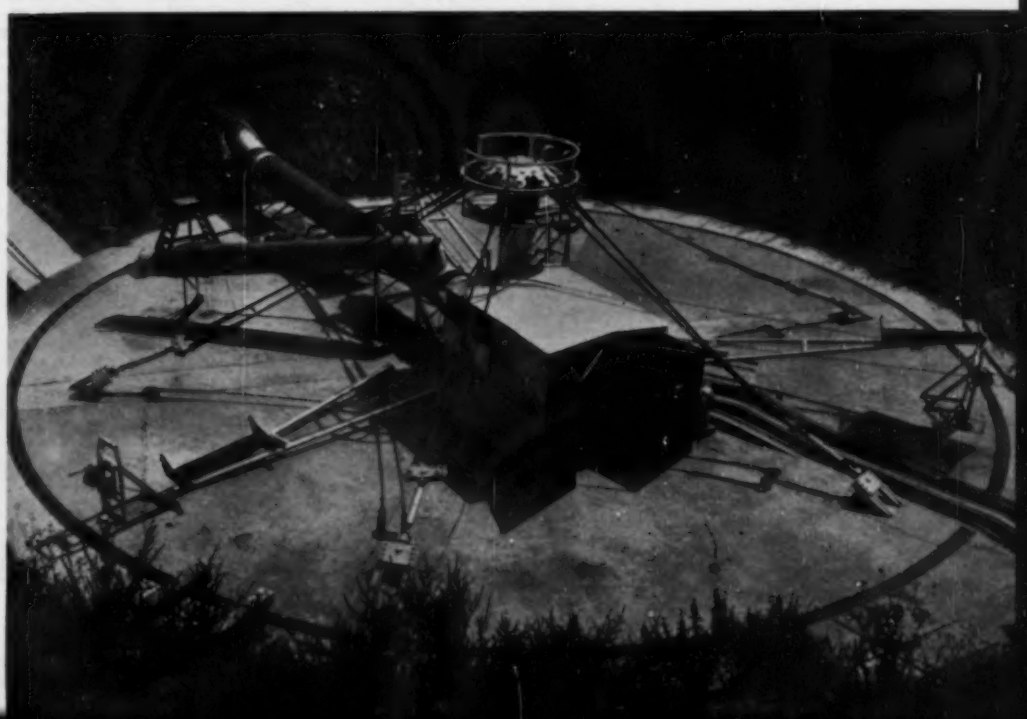
IN future, at least two airframes of each new pressurized civil prototype will have to be made available, for static and fatigue testing respectively, under a new A.R.B. policy for pre-service testing of airliners. The policy stems, of course, from the lessons of the Comet inquiry, where it was first announced by the Attorney-General, Sir Lionel Heald, on November 12th. Sir Lionel's statement is quoted in full on page 732.

Fatigue-testing of pressure cabins will be undertaken in water tanks of the type built by the R.A.E. at Farnborough during the Comet investigations. We understand that a new, larger tank is to be built there for testing the Britannia fuselage. Vickers-Armstrongs have announced that they are building a tank at Weybridge for trials on a Viscount airframe.

Javelin Search Continues

THE search for the Javelin which came down in the Bristol Channel on October 21st is still continuing. The Naval vessels engaged in sweeping the area have on several occasions made contact with the aircraft or with parts of it (as proved by paint-marks on the sweep wires), but the exact position of the contacts has not been fixed. Since further sweeping is unlikely to produce results it has been decided to search with divers alone. Despite the turgid water and strong tidal currents this method is felt to offer a reasonable chance of success, given good weather and a measure of luck.

All Naval vessels hitherto operating have now been withdrawn with the exception of H.M.S. *Flatholm*, which will act as parent ship for the divers. Operations last week-end were considerably hampered by exceptionally high tides. Meanwhile, Javelins are reported to be once more cleared for flight.



***WHIRL PIT:** This testing pit, on the airfield at Luton, has been built by Percival Aircraft for the development of helicopter rotors (it is now a requirement that new rotor designs shall be tested to destruction). At present a Derwent is being used to simulate the gas-supply from a Napier Oryx, but shaft-driven rotors can also be accommodated. Tests are observed from a protected shelter at the side of the pit.*

FROM ALL QUARTERS . . .

Marathon and Valetta Inquests

AT a Chippenham inquest on November 9th it was said that the wing-tips of a Marathon aircraft came off in the air before it crashed at Calne, Wilts, on September 30th, with the result that all five of the crew lost their lives. S/L. L. A. E. Osbon told the Coroner that there were only eight of this type of aircraft in service. He agreed with the Coroner that there was a joint at the place where witnesses stated that the wings became detached, and that the matter was perturbing. Verdicts were recorded of accidental death in an aircraft crash, due to the wing-tips coming off through a cause unascertained.

A second inquest at Chippenham on November 9th was on P/O. Albert Robertson, who was killed when a Valetta from R.A.F. Station Dishforth crashed on January 20th. The aircraft was carrying families of personnel to the Middle East and is said to have stood on its tail when about 100ft up after taking off. F/L. R. D. Topley (who lost a leg in the accident and is now learning to walk again at a rehabilitation centre) said that the take-off from Lyneham was normal, but that behaviour at 100ft indicated that something was wrong with the elevator control. When the aircraft continued to rise and went into cloud, he tried to right it by using the throttles, but it went into a shallow dive. He remembered hitting a big tree. Unofficially he had been told that the court of inquiry had found a defect in the elevator control, which would account for the aircraft's behaviour.

Provost Deliveries

THE six Hunting Percival Provost T.53 armed trainers which, as already recorded, left England on October 26th, arrived at Mingaladon airfield, Rangoon, on November 7th. These six are the first of a larger batch ordered for the Burma Air Force and their flight of over 6,400 miles was made by pilots of Fieldair Ltd. With the exception of delays due to seasonal weather, the entire undertaking went through without incident. To support the B.A.F. in the initial stages of operating the Provosts, representatives from Hunting Percival Aircraft, Ltd., and Alvis, Ltd., accompanied the flight and will remain for a period in Rangoon.

Before the Burmese Provosts had set out from Croydon four machines of similar type for the Royal Rhodesian Air Force were on their way to Salisbury, Southern Rhodesia, which they reached on November 5th. They were flown out in stages from Benson Airfield, Oxford, by R.R.A.F. crews, and had left on October 25th.

"WAR IN THE AIR" TV SERIES BEGINS

THE first episode of the B.B.C.'s long-awaited historical documentary film "War in the Air," telling the story of the impact of air power on world affairs, was televised on Monday, November 8th. Entitled *The Fated Sky*, it covered the period from 1935 to 1940, during which the Luftwaffe was formed, the Hurricane and Spitfire put into production, that "bit of paper" signed in Munich, war declared, and Poland overwhelmed, followed by Denmark, Norway, Belgium, Holland and France.

Whilst the strength of the Luftwaffe was being built up Britain concentrated upon her air defence. This was based upon three "new ideas": the introduction of the Hurricane and Spitfire; the setting up of "radio direction-finding" (radar) units to give early warning of the approach of hostile aircraft, and the organization and equipping of the Ground Defence units. The shot of "Mutt" Summers taking the prototype Spitfire up for its maiden flight must have revived nostalgic memories for many viewers, as must the views of Hurricanes and "Wimpeys" under construction.

With so much happening it is hardly surprising that many important events were perforce covered sketchily. Thus, the foundation of the Luftwaffe was covered by the statement that it consisted of "2,000 'planes and 20,000 men," followed by brief shots of He 51 biplanes, Ju 52s and Ju 87s taking off. One would have liked to have seen more of this vital phase of the growth of air power.

More serious was the failure to stress the part played by the Royal Air Force during the Dunkirk operations. The film was a golden opportunity to correct the belief, still held by many, that little was done to prevent enemy strafing of the crowded beaches. The fact is that, in the three weeks or so preceding and during the evacuation, the Royal Air Force lost 432 aircraft in defending the beaches, whilst enemy losses exceeded 1,200 aircraft, It was in the skies beyond Dunkirk that the pilots of Fighter Command scored a victory second, perhaps, in importance only to the Battle of Britain, and which contributed largely to the escape of over three hundred thousand Allied soldiers.

As with the earlier American documentary film *Victory at Sea*, some of the most interesting shots in the film were those taken by enemy cameramen. A dramatic sequence showed German paratroopers boarding Ju 52s at night. Others showed a bomb from a Ju 87 scoring a direct hit on a tank that could not have been very far from the cameraman, and a sad shot of a Lysander hitting the sea.

Perhaps the most useful lesson of this first episode was the importance of radar to the home defences. It gave us, in the words of the commentary, "A new horizon in the form of a pale green line across a cathode-ray tube." After the fall of France (at which point this instalment of the film ended) Britain's first line of defence indeed lay in the invisible radar signals emanating from the tall mysterious lattice-work masts erected at strategic points round the South-east coast.

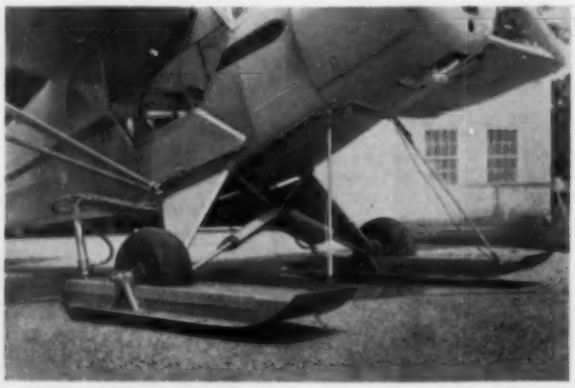
"War in the Air" comprises a series of 15 films, which are being televised on Monday and Saturday evenings. M.F.A.

VERSATILE LANDING-GEAR

THE Piper Cub seen in the photographs below is equipped with an experimental "Universal landing-gear" developed from hydro-ski research by the All-American Engineering Co. As can be seen from the close-up view, the incidence of the skis is adjustable in flight through the medium of hydraulic jacks. Landings on runways or grass are made with the skis in the horizontal position shown, the hydraulic valves being so adjusted that the skis can rock freely to accommodate themselves to the irregularities of the surface; with the mainwheel axles as their fulcrum points, they are restrained by elastic cords, a slack check-wire being included.

An aircraft fitted with these skis, it is stated, can take off or land with equal facility on normal surfaces or on ice or snow, and it can also operate from water provided there is a beach or ramp on to which it can run as soon as high-speed taxying is completed, or from which it can start. In regular operation, some form of flotation gear would presumably have to be carried, since the skis would not act as floats in the event of an engine failure during taxying.

Equipped with the special ski gear shown on the right, the Piper Cub taxies at speed from the water to a ramp.



COMET INQUIRY: THE FOURTH WEEK

Evidence for the Crown Completed: New A.R.B. Requirements Announced

DURING the fourth week of the Comet Accident Inquiry, the final witnesses called by the Crown gave evidence, and Sir Lionel Heald revealed details of proposed new A.R.B. certification requirements. Sir Lionel also propounded the questions which the commissioner and his three assessors would be expected to answer in their subsequent report. For the fifth week, when the Court was to move from Church House, Westminster, to the Institution of Civil Engineers, further witnesses would be called by the de Havilland company, and final speeches were to be made by counsel representing the various interested parties. This week's report of the Inquiry begins on pages 740-742, and is continued on this and the following page.

Thursday, November 11th: Fifteenth Day.—The chief structural engineer of the de Havilland Aircraft Company continued his evidence, and was cross-examined by counsel concerning his department's calculations of stress levels in the Comet pressure cabin. The Crown's examination of Mr. R. E. Bishop, the company's chief designer, was begun.

Under continued examination by Mr. J. P. Graham (for the Crown), Mr. R. H. T. Harper (de Havilland chief structural engineer) gave further details of the structural test programme on the Comet. In the whole of the Comet project, he said, the company had carried out 500 test investigations, involving some thousands of actual tests. It was his belief that even before the Comet went to Farnborough for the tank test, it was the most tested civil aircraft in this country.

In order to investigate the cabin pressurization, temperature and humidity controls, Mr. Harper continued, a large decompression chamber was installed at Hatfield. It was decided to design the Comet to a calculated ultimate factor of 2.5, and to demonstrate by test that the fuselage test specimens would be capable of withstanding a factor of 2 without any permanent deformation. Two fuselage test specimens were constructed, 26ft and 24ft long respectively, representative of the nose section (and including the ADF windows) and centre section (including the cut-out for the wings and the pressure floor); these were used for both strength tests and functional tests. On final water-pressure tests, 16 lb/sq in was achieved without serious deformation.

After mentioning the separate testing carried out on wings, tail unit, undercarriage and flying controls, Mr. Harper gave examples from specific fuselage tests. In one, a fuselage section containing a cabin window was pressurized to 19¾ lb/sq in before failure; for that reason, strain-gauging around the window was not considered necessary in subsequent tests on the full nose section. The initial test programme for the nose section comprised three parts: (a) pressurization to 13.5 lb/sq in, (b) 2,000 reversals of 9 lb/sq in, followed by one loading to 11.69 lb/sq in, and (c) pressurization to 15 lb/sq in. "We used strain-gauges in this particular case," the witness stated, "as a warning of an impending failure. We were not using them to predict an exact stress."

Further tests in 1948 and 1949 proved that the nose section would withstand 16.5 lb/sq in, and by 1953 it had in addition been subjected to a total of 18,000 reversals of at least working pressure. The centre section was also shown to be capable of withstanding 16.5 lb/sq in. Among the tests on the wing was one of 5,000 repeated applications of load, and fatigue failures were experienced. Certain portions of the wing were subjected to further repeated-loading tests at Hatfield and Farnborough, and the prototype Comet itself was sent to the R.A.E. in late 1953 for fatigue testing. Questioned by Lord Cohen, Mr. Harper then described the extent of co-operation between de Havillands and the R.A.E. during the tests.

Cross-examined by Mr. L. G. Scarman (for the A.R.B.), Mr. Harper agreed that the Air Registration Board, while not lightly or frequently changing their requirements, did pass on their ideas on new problems to companies such as de Havillands. One example, showing the Board's awareness of the wing-fatigue problem, had been its opinion, expressed to de Havillands, that flight experience of gusts should be confirmed over a long period by the fitting of gust recorders to a proportion of the Comet aircraft. In the case of civil aircraft which were likely to be in operation for a considerable number of years, the Board had expressed the opinion that fatigue due to repeated loading would become a main design criterion.

In reply to Mr. J. M. Shaw (for the relatives of a number of the deceased crew-members and passengers), Mr. Harper said that as a result of the company's calculations and tests he was satisfied that the stresses in the pressure cabin did not exceed 50 per cent of the ultimate. The witness did not accept the extrapolated figure of 70 per cent, stated in the R.A.E. report to be the edge stress at an A.D.F. window, but thought that the stress would decrease from the rivet line to the edge.

The witness said he thought that, in future, they would have to work to a lower general level of stress than 50 per cent to cover the "inequalities"—locally high stresses such as might have been present at the countersunk bolt-hole on YP where, it seemed, fatigue had occurred. In considering a future aircraft, he continued, the only answer to the fatigue problem around cut-outs was to do more testing.

Explaining why he thought calculation alone could not be relied on, Mr. Harper said "If one takes a simple riveted joint which has an average stress through the net area of the rivet holes of 30,000 lb/sq in, theoretically that stress will go up to three times that amount at the rivet holes, which would suggest that if the ultimate of the material is round about 60,000 lb on one application of load, it would break because the stress at the rivets is in fact three times 30,000 lb, which would bring it up to 90,000 lb, and the material is only good for 60,000 lb. Not only statically does it take its ultimate load and achieve a correct ultimate stress, with no loss whatsoever due to stress concentration if it happened to be a material like D.T.D.746 but, if you use fatigue tests, it will probably take in the order of 10,000 to 20,000 reversals, which shows that these peak stresses either disappear or become altered under load, and so one must resort to fatigue tests of the particular piece of structure under consideration and you cannot refer it back to S/N curves."

Further questions from Mr. Shaw concerned the rivet holes found to have been drilled nearer the edge of A.D.F. windows on YU and YP than laid down on the design drawings; and manufacturing cracks and their correction. The test nose-section, Mr. Harper admitted, had been altered by repairs after the first 2,000 reversals of load, and before the subsequent 16,000. Concerning Dr. Walker's suggestion that the insertion of new parts might significantly alter stresses, Mr. Harper thought it would depend on the nature of the original failure; he personally thought it would alter the distribution only locally. Repeated-loading tests for the immediate future, he thought, should be made on complete fuselages.

Mr. R. A. MacCrindle (for the British Air Line Pilots Association) next questioned Mr. Harper on the relative importance to be attached to calculation and test results, and the discrepancy previously mentioned in Court between de Havilland calculations of the stress near the edge of a cut-out and those made by Sir Arnold Hall "on the back of an envelope" when returning home one evening during the third week of the Inquiry. (The de Havilland figure had been 26,000 lb/sq in, while Sir Arnold's answer had come to between 36,000 and 40,000 lb/sq in.) A de Havilland statement referred to Sir Arnold's calculation as "a most valuable as well as novel contribution to the philosophy on this topic, of which important use will be made in the future." Mr. Harper stated that the two methods of calculation were broadly similar: "The results did not depend on mathematics, they depend on opinion."

In reply to Mr. T. Humphrey Tilling (for the Navigators and Engineer Officers Union), Mr. Harper said that he would not attempt to estimate fatigue life either on calculated figures or strain-gauge figures; he would do it only as a result of fatigue testing. It was impossible to reproduce every relevant factor in the tests, he said, but the safety margin allowed would cover those factors not simulated.

Questioned whether particular failures experienced during the test programme had been forecast by calculation, Mr. Harper said that, at the ultimate condition for the nose-section, strain-gauges had indicated maximum stresses approximately 70 per cent of the ultimate stresses estimated. Pre-loading and its possible effect on the repeated-loading test figures had been appreciated in considering the test results.

Describing the company's wing tests, under cross-examination by Mr. Rodger Winn (for de Havillands), Mr. Harper confirmed that the repeated loadings (5,000 applications of 10-40 per cent of ultimate) were applied before the test to ultimate static strength and that having been weakened by previous loadings, the wing failed at 85 per cent of ultimate.

Mr. R. E. Bishop, chief designer at the de Havilland Aircraft Co., was the next witness. Under examination by Sir Lionel Heald (for the Crown), he described the design history of the Comet.

COMET INQUIRY: THE FOURTH WEEK . . .

Concerning a previous reference to the question of cabin differential pressure, the witness said, "I personally thought it was one of the biggest problems that we had to face, since we were very alive to the consequences of a failure. It was quite obvious right from the start that if the structure of the pressure cabin failed or if a window blew out at 40,000ft, it was at least a very serious situation; and a great deal of thought and testing was done with the object of making sure that that pressure cabin was safe. We obviously missed the main point."

After describing the use of the de Havilland water tank and the decompression chamber, Mr. Bishop said that he thought the decision to use powered flying controls for the Comet was a correct one; "The Comet flies at a Mach number up to about 0.75 where big changes take place in the flow round the wings, the aeroplane has a big speed range, and we felt that the power control was the surest way of dealing with these problems."

As mentioned previously at the Inquiry, Farnborough test pilots had expressed a preference for a smaller break out force on the elevator control. A de Havilland test pilot, Sir Lionel stated, had said "Although the break-out force is undesirably high, experience has shown that once a pilot has become used to the feel of it, it ceases to present any real difficulty." In reply to Lord Cohen, who suggested that an "undesirably high" force should not be retained without reason, Mr. Bishop said that it took time to make such changes; a Comet III was now flying with reduced break-out forces, an improvement which was being considered for the Comet II also.

At a joint meeting of Ministry of Supply and de Havilland representatives at Hatfield in May 1947, the tests to be performed on the prototype Comet had been discussed, Mr. Bishop said. Although repeated-loading tests were agreed at that time for the wing, they were not called for on the fuselage until 1952. Concluding his background information on Comet development, Mr. Bishop repeated that, although there was earlier theoretical knowledge of fatigue, it did not begin to be seriously considered as a practical problem until about the beginning of 1952. "We thought we were covered by these tests that we had done, and it was a very great surprise to me personally when the fuselage blew up in the tank at 9,000 hr. We thought we had a very much longer life than that."

Friday, November 12th: Sixteenth Day.—The chief designer of the de Havilland company continued to give his evidence, and was cross-examined by counsel. Mr. Bruno Jablonsky amplified his previous evidence concerning the use of Redux in the Comet, and de Havillands' general production manager discussed manufacturing cracks. The proposed new A.R.B. requirements were outlined by Sir Lionel Heald, for the Crown.

Under continued examination by Sir Lionel Heald, Mr. R. E. Bishop said that he agreed with the conclusions of the R.A.E. report as to the cause of the accident to YP. Non-contributory defects such as those in the fuel venting and pressure refuelling, and wing fatigue, were being dealt with; concerning this last factor, Mr. Bishop thought it had had no bearing on the Naples accident because YY had been inspected for wing fatigue only 30 hr before the accident occurred.

Of the future, Mr. Bishop said: "I do not think anybody need have any fears that we cannot put this right. . . . It is only very recently that aircraft designers realized that there was a problem of fatigue in pressure cabins. As regards the way we shall tackle it, I do not entirely agree with Sir Arnold Hall. I believe he suggested that we should have a tank test to find the points of failure, and then make a large number of specimens. We cannot quite afford to do it that way round. I think we shall have to make a large number of specimens first. In fact, even before that we shall start to establish a detailed design technique. We have already started that, which will mean a very large number of small tests—tests of riveted joints, of methods of reinforcing riveted joints, and especially of things which affect fatigue in these thin metal structures. The next stage will be to build a large number of relatively small test pieces, if you can imagine them as sections of the fuselage, with the areas of high stress—the window cut-outs, nosewheel cut-out, and things like that—and build quite a number of those and use strain-gauges as far as we are able. I am quite convinced that we cannot put strain-gauges very often in the most vital places. Strain-gauges, to my mind, are only a tool, not an answer to everything. Then, finally, I believe we shall have to finish up, for a few years anyway, with a major tank test with the wings on the fuselage . . . "

Cross-examination by counsel followed. Replying to Mr. MacCrindle concerning future modifications to Comet fuselages, Mr. Bishop said: "We shall increase the thickness of the fuselage skin, but as well we shall have to reduce the local concentrations around cut-outs." The witness agreed with Mr. Tilling that the Comet had originally been designed for two-crew operation, but that every operator using Comets had always carried a separate engineer as a third crew-member; but did not agree that, from the 2nd pilot's/engineer officer's position, the engineer could not reach all the necessary controls.

Mr. Bishop agreed with Mr. Rodger Winn that a peeling test was applied to a test-piece at the end of every Reduxed stringer used. During Dove and Comet production, 180,000 such tests had been made, and in the structural test department 425 separate structural tests of Redux joints had been performed.

In reply to Mr. J. Whitford (for Aero Research, Ltd.), Mr. Bishop said that his company had used the Redux process before 1946—on the first Dove, in 1945. Since then it had been used in addition on a number of fighters, whose high rates of climb would cause faster temperature-changes between skin and stringers than on civil types.

Earlier, Mr. Bruno Jablonsky had been recalled to give further evidence, following his consideration of Redux test data from de Havillands and Aero Research, Ltd. Reading a long prepared statement, he pointed out that his first letter on the subject of possible failure of glued parts in the Comet had been sent to Lord Brabazon at the beginning of April, followed by one to Sir Miles Thomas.

Referring to a de Havilland test report on Redux joints, Mr. Jablonsky continued, "The tests give full marks to the adhesive as such, but they do not prove how the adhesive would have behaved if simultaneous loads on one side had been applied and if expansion and contraction had had any chance to come into operation under normal stress-loading in the fuselage. . . . These tests, therefore, are a completely unsatisfactory foundation for the application of the method to quantity production of large complex structures."

Summing up his case, Mr. Jablonsky made the following points: "(1) Latent defects in glue-lines may be produced by manufacturing imperfections or by temperatures in tropical climates, having regard to normal loads on aircraft structures. (2) Changes in temperature of the structure and the glue-lines when the aircraft goes from the ground (sometimes in tropical temperatures) to the very low temperatures of about −55 to −60 deg C in too short a space of time, will produce contraction of parts of the fuselage on the upward flight and expansion on the downward flight. (3) This contraction and expansion of the skin will produce excessive stresses leading to the loosening and rupture of the glue-lines. Such loosening and rupture of the glue-lines will lead to excessive stresses appearing in other parts of the fuselage. (4) Such additional stresses in parts of the fuselage may lead directly to failure of the structure." These conclusions, he said, were supported by the evidence of parts of the wreckage of Y.P.

Sir Lionel Heald next stated that he had now examined all the witnesses whom he thought it was proper should be called before the Court, but that Mr. Rodger Winn (for de Havillands) would be calling further witnesses on specific points.

"I have been hopeful from the very beginning of this inquiry," Sir Lionel continued, "that it might be possible for me, as representing the Crown in the interests of the public, to put before the Court some suggestions, however broad in outline, as to how the machinery for ensuring the safety of civil flying might be strengthened and improved . . . I have therefore consulted the Ministry of Transport and Civil Aviation and the Air Registration Board, and I am glad to be able to inform the Court on certain practical steps which the Air Registration Board propose to take, with the Minister's approval, as a result of the consideration that they have both been giving to this matter for several months past.

Fatigue Testing of Future Prototypes

"In the first place, the Board has already indicated its intention that complete cabins of pressurized aircraft shall be submitted to tank tests similar to those used at Farnborough, at any rate until knowledge of the fatigue problem has become much more exact. Before the certification of certain prototypes can be contemplated by the Board, therefore, provision will now be required for fatigue testing of entire components, and in the Board's view at least two airframes of each prototype will have to be made available, one for static testing and the other for fatigue testing."

Secondly, Sir Lionel went on, "one or more additional members specially selected for their eminence in the scientific field" were to be included on the council of the A.R.B., in view of the difficult problems facing aircraft designers and the Board.

"Various other measures are under consideration, but I do not think it would be of assistance to the Court to go into these in detail. I may, however, perhaps usefully mention two points. First, a purely practical matter, the value of test flights in the shape of extensive flying on proposed routes with fully instrumented aircraft, especially in relation to aircraft with engines of which there is no background of experience, for example, in the Royal Air Force. The second point is concerned with research. As you have heard in evidence, the Board has been concerned for some time about the structural integrity of modern high-performance pressurized transport aircraft. The importance of research on fatigue in aircraft has also become increasingly apparent in recent years and much valuable work has been done on this by the Air Registration Board, in the Industry and in the Ministry of Supply. In particular, research on the problem of fatigue in high-grade light alloys has been sponsored for a long time by the Ministry of Supply and work on the programme has been intensified during the past two or three years. The subject is continually before the appropriate Committees of the Inter-Service Metallurgical Research Council. Although the subject is a difficult one and rapid results cannot be expected, it is fully recognized that the best brains and resources ought to be directed to it, and the Ministry of Supply has agreed to give the fullest co-operation in this work."

Sir Lionel went on to propound the questions, the answers to which would form the basis of the official findings of the Court.

The first witness to be called by the de Havilland company, Mr. H. Povey (general production manager), next described the company's concession system, under which faults in manufacture could be rectified, and referred to a crack, not covered by a concession note, found in the aircraft skin near the rear A.D.F. window on YP.

Concerning this skin crack, Mr. Povey said: "My personal opinion is that at the time the inspection was made there was no crack there, and I think that during the assembly some accidental damage may have happened; obviously the workman had seen the crack, because the crack at this stage, as you know, had been drilled at both its extremities. I think that he probably omitted to call the attention of the supervisor or of the inspector, and unfortunately they closed the assembly; and once it was closed the inspector would not have an opportunity of inspecting that portion of the skin again."

He could give no other explanation, and it was quite clear it should not have happened. Pointing out that the company depended on the integrity of the workmen in disclosing any defects they found or made, he said that the preparation of a pamphlet was being considered which would assist new operators to realize the importance of reporting the smallest defect.

(*To be continued*)

B.O.A.C.'s EQUIPMENT

The Britannia Situation: Interest in the DC-7D: Present and Planned Fleets

HEADLINES, surmises and statements about B.O.A.C.'s fleet plans, and more particularly about the Corporation's interest in the DC-7D, have probably left a lot of people rather confused about the whole situation. The important points which emerge, however, have not changed since they were first discussed several weeks ago. B.O.A.C.'s first duty is to operate air passenger services, and it is also the Corporation's desire to operate them profitably and with British aircraft. But their experience since the war with British airliners has been unfortunate.

One of the things an airline—particularly one with a highly competitive world network—must be able to do is plan well ahead. B.O.A.C.'s North Atlantic services for the late 1950s depend entirely on two unknown quantities: the long-range Britannia and the Comet 3. There are no alternatives in view in this country although it is just possible that, were an all-out effort to be made, Avro Atlantic, H.P.97 or even Vickers VC-7 airliners could be built and ready for service before 1960. But these again would be unknowns. Thus, purely as an insurance, B.O.A.C. have been looking into the possibilities of a Douglas DC-7 development—the proposed D series—with Rolls-Royce R.B. 109 turboprops. These machines could not be available before 1958 at the earliest, and the engines would be quite new to service.

Assuming that the engines are successful and are not delayed by unforeseen troubles, the DC-7D might be an attractive North Atlantic aircraft for 1959, frequently able to handle the direct crossing to or from New York. This elusive direct flight with regularity is still the plum for which airlines are striving. The long-range Britannia 300 with Proteus 755 engines would be an operating contemporary which should, in fact, enter service considerably in advance of the DC-7D. B.O.A.C. say that it is too early as yet to state whether the Britannia 300 (with long-range tankage) will be used on the North Atlantic route. It should be a better aircraft for the passenger and should carry a greater payload for the Atlantic operator. Not far behind these two is the later Britannia-type machine with Bristol B.E.25 supercharged turboprops. This should show a very big improvement over both its predecessors and the DC-7D, and be a London to New York direct crosser all the year round.

While understanding B.O.A.C.'s predicament, we should naturally regret the placing of an order in America; an all-out (if need be, national) effort should be made to bring the Britannias on and gain the requisite experience with them. On the positive side, in the event of a B.O.A.C. order for DC-7Ds, would be the encouragement to others to operate Douglas aircraft with British Rolls-Royce turboprops. The 4,000 s.h.p. R.B.109 is primarily intended for the Viscount's successor—a larger and faster machine. The R.B. 109 is approximately half the size and is capable of producing half the cruising power at altitude of the B.E.25.

The following statement was issued by B.O.A.C. last Friday evening, with an introduction saying that it concerned "a newspaper report that 'B.O.A.C. is buying American again':—

"(1) B.O.A.C. has never denied taking an interest in a proposed DC-7 aircraft which would have an airframe built by the Douglas Aircraft Company, of America, and would be equipped with a powerful new British turbo-propeller engine produced by the Rolls-Royce Company. No order for this aircraft has been placed.

"(2) No order for the Britannia in any of its various forms has ever been cancelled or reduced. We need and believe in the Britannia.

"(3) B.O.A.C.'s original contract for 25 Britannia aircraft was signed in July 1949. Since that date, more than five years ago, no individual Britannia aircraft has yet flown pressurized for more than a total of 120 hours. The aggregate test flying time of all Britannias ever built does not to date exceed 600 hours and the majority of this flying has been done unpressurized.

"(4) Naturally, B.O.A.C., in the light of Comet experience, is demanding additional Britannia pressurized test-flying. Moreover, B.O.A.C. pilots are co-operating in this extended test-flying.

"(5) Since the Britannia contract was placed five-and-a-half years ago no material changes in the airframe specification have been requested by B.O.A.C. The Bristol Company has progressively offered alternative engines—first the Proteus II, then the Proteus III, then the Proteus 705, and finally the 755, which is now to be fitted to the second series of Britannias on order. Their proposal to fit another new engine—the B.E.25—is being examined by B.O.A.C. All these engine developments aim at improving the already good specification and B.O.A.C. welcomes the proposals.

"(6) The original Britannia design—known as the Medium Range Empire specification—was never visualized for trans-Atlantic operation. Only the later proposed engine design developments have opened up this possibility.

"(7) The contract delivery dates for the first 25 Britannias were from May 1954 to October 1955.

"(8) B.O.A.C. has already paid £6,640,000 to the Bristol Aeroplane Company as progress payments.

"(9) The Corporation would always prefer to buy British aircraft made in factories on its doorstep, instead of from a firm which may be 6,000 miles away.

"(10) An independent British airline is buying new American Douglas aircraft with American engines. [Two DC-6As for Airwork.—Ed.] B.O.A.C.'s study of the Douglas/Rolls-Royce project includes the provision of British-made engines, which would involve a sterling, not a dollar, expenditure. There is no British trans-Atlantic airliner suited to take this Rolls-Royce turbo-propeller engine."

Sir Miles Thomas, chairman of B.O.A.C., added:—

"You cannot carry passengers on promises—and as B.O.A.C. is engaged in a vigorously competitive international business it is vital that we, as a British airline, should be in a position to offer present and future passengers throughout the world aircraft which are as up-to-date as those of any of our competitors.

"It is our duty to look ahead and to examine the potentialities of any prospective new airliner which might be appropriate for use either by us or by those competitors, particularly one which is to be fitted with British-built engines.

"Today, B.O.A.C., which is supporting the British aircraft industry with orders to the value of more than £50m, has on order only two types of aircraft, both of them British—de Havilland Comets and Bristol Britannias. It is our firm policy to buy British whenever possible. But it is also our statutory responsibility to operate an airline. To do so we must have the right aircraft. Moreover, it is essential that we should have them at the right time if we are not to lose trade to the airlines of other nations."

At the end of the financial year 1953-54, B.O.A.C.'s revenue-earning fleet consisted of 22 Argonauts, 11 Constellations, ten Stratocruisers, seven Comet 1s and four York freighters. Shortly afterwards Comet 1s were withdrawn from service, reducing the planned capacity for the financial year 1954-55 by 21 per cent.

The immediate outcome of this loss of capacity was the suspension of the South American services flown by Argonauts. Next came the re-introduction of four Hermes on the East African routes, reducing slightly the load on the Argonauts, which had taken over most of the services formerly flown by Comets (to Johannesburg, Ceylon, Singapore and Tokyo).

In addition to the loss of Comet 1 capacity, the Corporation also had to face the problem of indefinite delays of Comet 2s. These aircraft were to have been used on the South American and Australian routes. No precise date for the introduction of Britannias had been announced.

Consequently, little surprise was occasioned by the announcement, in July, that B.O.A.C. would, as an interim measure, acquire 16 additional American aircraft—eight Stratocruisers and eight Constellation 749As. Delivery was to be spread over a year.

The effect of this decision will be to increase B.O.A.C.'s Stratocruiser and Constellation fleets to 18 and 20 aircraft respectively. Incidentally, six early-type Constellation 049s are being exchanged for six 749As of Capital Airlines (who receive a cash adjustment), for standardization and extra payload-range performance.

The deployment of the B.O.A.C. fleets is as follows:—

Stratocruisers, used only on first-class Atlantic services, operate to Canada, the United States, Bermuda and the Caribbean. Constellations cover approximately the same routes and also operate B.O.A.C.'s share of the Kangaroo route to Sydney. Argonauts serve the Middle East, Africa, India and the Far East.

During the coming year, when the Stratocruiser fleet reaches full strength, these double-deck aircraft will take over all the North Atlantic services. The release of Constellations from this route, together with an expansion of the existing Constellation fleet, will enable B.O.A.C. to resume the South American services, and also to begin "phasing-out" Argonauts—particularly on the major first-class routes, such as Johannesburg and Tokyo. Nevertheless, it is not likely that the Corporation will be ready to dispose of its hard-working, well-proven Argonauts in the near future. A few might be relegated to freighting duties, replacing the Yorks now operating the regular cargo service to Singapore.

Britannia 100s will probably first be introduced on the East and West African routes, both for first-class and tourist services. When South American services are resumed—and this is unlikely to be before mid-1956—749A Connies will probably be used. At this time other 749s will be handling tourist services to the East as well as first-class services on the Commonwealth routes.

B.O.A.C. now have on order twelve Comet 2s and five Comet 3s with an option on five more. Contrary to some reports, the 44-seat Comet 2, if proceeded with, would incorporate recent developments including improved Avons, which would more than offset the weight increase and loss of payload due to airframe stiffening. In view of the time involved the opinion has also been expressed that it would be better now for B.O.A.C. to go all out for 3s, which are larger and more flexible to operate.

HERE AND THERE

SWEDISH AIR DRILL: Saab 29s exercising in echelon formation under a pale northern sun. Fighters of this type will soon be accounting for about 50 per cent of the total annual flying time of the Royal Swedish Air Force.

Aircrew Training Cost

IN answer to a question in Parliament on November 10th, Mr. Ward, Under-Secretary of State for Air, gave some figures on the cost of training R.A.F. aircrew up to the time they join a squadron. For a pilot the sum is £25,000, for a signaller £15,000 and for a flight engineer £8,000.

Col. de Rancourt's A.A.F.C.E. Post

IT is learned that Col. H. de Rancourt, D.F.C., has been promoted to the rank of Général de Brigade on his appointment as Assistant Chief of Air Staff (Training), Allied Air Forces Central Europe. He was well known in this country during his term of office as Air Attaché at the French Embassy in London, in which post he was succeeded by Colonel A. J. B. Puget, D.S.O., last July.

NATO'S NORTHERNMOST Air Command has adopted this badge, showing gold wings and the Northern Lights over the flags of the nations concerned—Denmark, Norway, Great Britain and U.S.A. The commander is Gen. Homer L. Sanders, U.S.A.F.

Venom and F-100 Restrictions

TEMPORARY restrictions were imposed last week on the flying of all de Havilland Venom and Sea Venom aircraft in the British Services. They forbid the use of wing-tip tanks and ban certain types of aerobatics and manœuvres. A D.H. spokesman has stated that the defect is not of a structural nature. In America, an order has been issued grounding all North American F-100 Super Sabres following three recent crashes, in one of which—as related on page 756—A. Cdre. D. G. Stephenson, Commandant of the Central Fighter Establishment, West Raynham, was killed. A. Cdre. Stephenson was heading a team of R.A.F. officers which was engaged in studying defence problems and operational procedures. In another recent F-100 crash Mr. George Welch, North American's chief test pilot, met his death in California. From a third machine of the same type the pilot parachuted to safety, sustaining minor injuries.

Unsound Vintage ?

A 1914-PATTERN Maurice Farman, being tested by Mr. Fred Edwards, who had spent two years in reconstructing it, crashed at Moorabin airfield, near Melbourne, last week. Mr. Edwards escaped with bruises.

Cockle-shell

THE world's smallest flying boat has been built by Turre Eklund in Finland. A single-seater, it has a 40 h.p. engine and carries fuel for 2½ hours' flying. Span of the folding wings is 24.6ft, top speed is 93 m.p.h.

From C.A.S. to C.A.S.

THE Chief of the Air Staff, Marshal of the Royal Air Force Sir William F. Dickson, has sent the following message to Generale De Squadra Ferdinando Raffaelli, the newly appointed Chief of Staff of the Italian Air Force: "I send you my warmest congratulations on your appointment . . . and wish you a happy and successful term of office. I look forward to continued friendship and increasing co-operation between our two Air Forces."

Swedish Jet Training

BASIC training in the Royal Swedish Air Force has been reduced from 235 to 180 hours under a new system—somewhat resembling the R.A.F. Provost-Vampire sequence—whereby trainees convert from the piston-engined Safir 91B to Vampires after 80 hours and then, after a further 75 hours, to the Saab J-29.

The Old Firm

A PHOTOGRAPHIC reconnaissance crew of the R.C.A.F. is composed of F/O. J. A. Mitchell (navigator), F/Sgt. T. E. Mitchell (photographer) and F/O. W. A. Mitchell (pilot). The aircraft—a B-25 Mitchell.

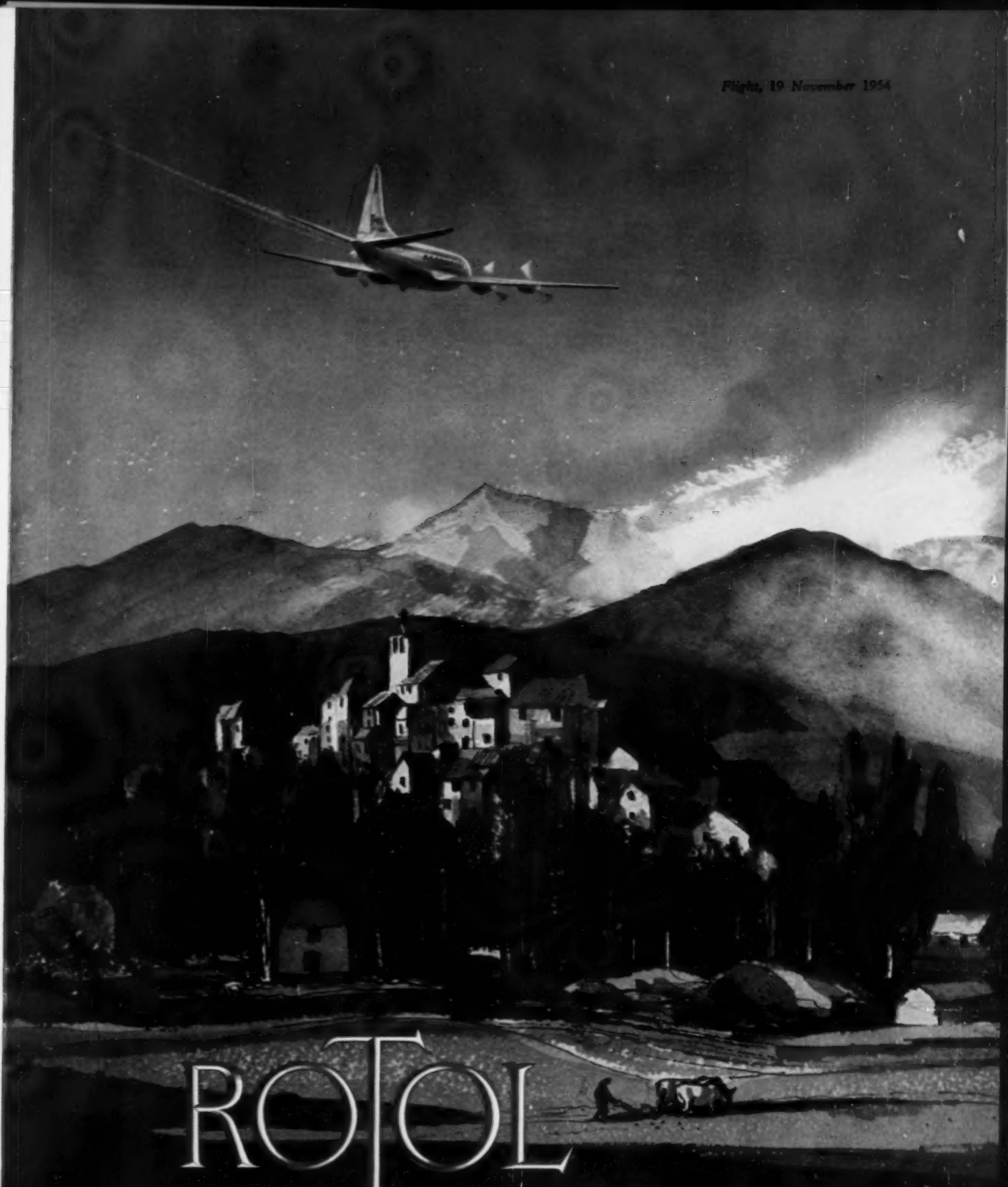
R.Ae.C. Film Shows Again

NEXT Tuesday, November 23rd, at 6.15 p.m., the Royal Aero Club is to hold its first film show of the winter season. The films will deal with the R.A.F. displays of 1928 and 1929 and with helicopters in the Belgian Congo, the latter production being by Leonard Thornhill. Admission is confined to R.Ae.C. members and their guests.

Canadair's Noise Abatement

A NOISE-LEVEL reduction of some 30 decibels has been achieved in engine running at Canadair's factory at Montreal after the installation of two types of silencer. One is of the pen type for complete aircraft and the other is a special test cell for engines alone. The system of silencers installed has cost some $100,000. Neighbouring shopping centres and a golf club have benefited considerably, but the problem of noise from aircraft taking off and landing remains.

THE AUSTRALIAN AIR MISSION, during its tour of British factories, visited the English Electric establishments in Lancashire. Seen here are (left to right):—A. Cdre. S. Graham (English Electric), Mr. G. D. Humphries (Commonwealth Aircraft), A.V-M. A. M. Murdoch (R.A.A.F.), Mr. I. B. Fleming (Dept. of Defence Production), Mr. F. W. Page and Mr. G. M. Hobday (Eng. Elec.), G/C. E. Hey (Dir. of Tech. Services, Dept. of Air), Mr. J. W. Adderley (Eng. Elec.), Mr. J. Hanford-Stevens (Dept. of Defence Prodn.), G/C. B. A. Heaton (Dir. of Ops., Dept. of Air), Mr. H. W. Hodgson (Dept. of Defence Prodn.).



ROTOL

PROPELLERS, GEARBOXES AND AUTOMATIC ENGINE SPEED SYNCHRONISING EQUIPMENT HAVE WORLD WIDE ACCEPTANCE.

near the Pyrenees from London in a Vickers Viscount.

SUPERMARINE SWIFT
AT328

MARTIN MIDGET

An Unorthodox Design for a Close-support Aircraft

IT is only rarely that anything approaching a full specification for a modern military aircraft can be published. Particular interest, therefore, attaches to a design-study for a light close-support machine prepared about two years ago by the Glenn L. Martin company and submitted to the U.S. Air Force.

According to the Martin company, the Air Force found nothing seriously amiss with the concept, but its development for production was not proceeded with, solely owing to a lack of sufficient budget funds at the time. The American journal *Aviation Week* has now disclosed details of the project and we have prepared a simplified perspective drawing of the aircraft, showing the principal features.

The theory underlying the design was that, in any future war, enemy ground forces would be highly dispersed and would adopt every possible expedient to reduce their vulnerability to air attack. It was considered that adequate close support for allied forces could be provided most efficiently by a wholly new, and specialized, type of aircraft; in 1951, when the design was formulated, the only aircraft available for such work were converted fighters—and the same obtains today, for that matter.

The Martin Midget, as the project was named, was to have been scarcely larger than the Folland Gnat. If it were to be resurrected it would certainly be supersonic; but the 1951 design had a straight wing, and the two small turbojets (of unstated type, but apparently Fairchild J44s with reheat) could have provided a sea-level speed of little more than 500 m.p.h. Manœuvrability, armour protection, structural strength, slow-speed characteristics, load-carrying ability and flexibility of operation were, however, to have been of a high order.

Speaking of the project in the present tense, for clarity's sake, it may be said that the general layout approximates to that of several German projects of six or seven years earlier, with a prone pilot housed in an armoured nose section which could be detached in emergencies and parachuted to safety. The control system is fully manual, and is conventional beyond the cockpit; the pilot's controls, however, are as shown in the inset sketch, the rudder being moved by turning the "spectacles" about a vertical axis. The pilot's feet are shown supported by pedals which control the wheel brakes. The levered-suspension undercarriage is itself of note, owing to the fact that the retracted main wheels lie almost in the tips of the wings.

Martin Midget Project

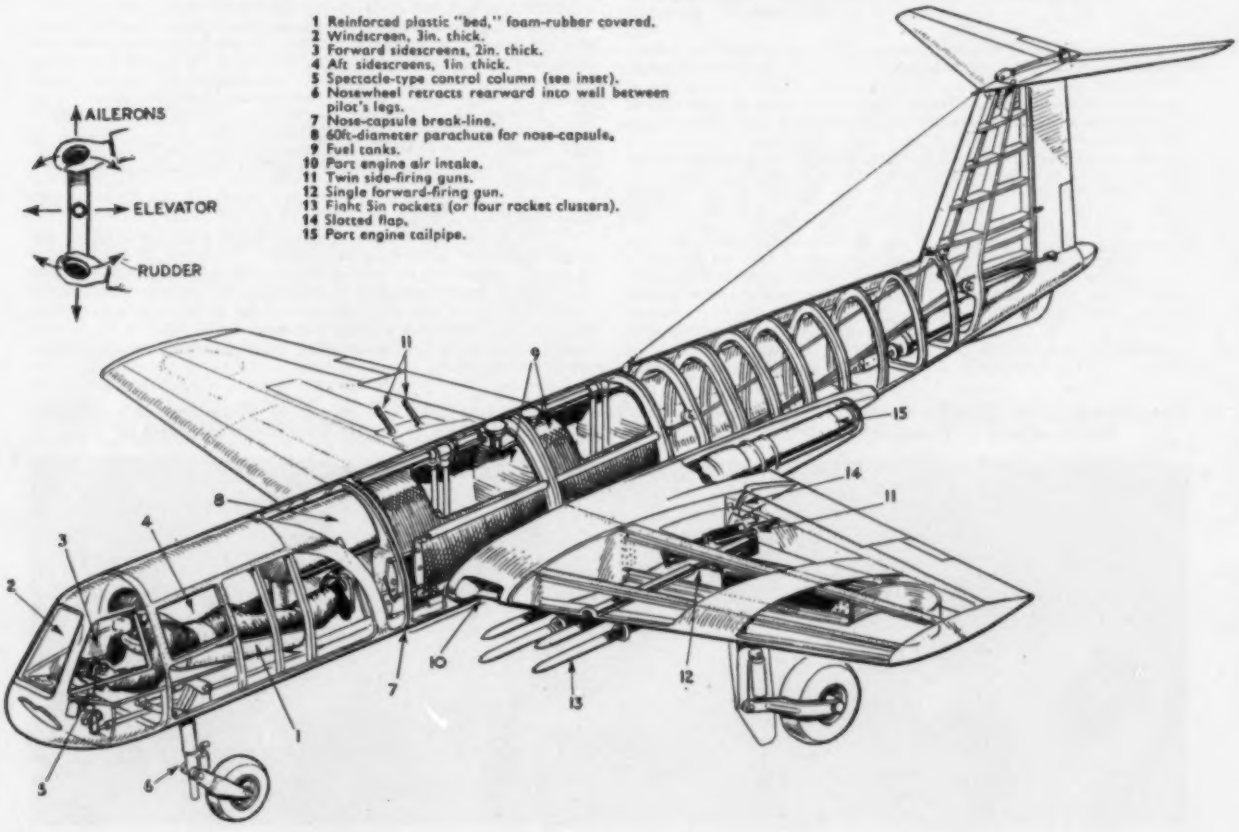
Two turbojets, with a total static sea-level thrust of 2,050 *lb* (3,280 *lb with reheat*).

Span, 23ft; length, 28ft 9in; height, 8ft 9in; tailplane span, 7ft 6in; empty weight, 3,666 lb; design gross weight, 5,686 lb; max. alternate gross, 7,726 lb.

Max. horizontal speed at sea level, 512 m.p.h.; minimum steady turn, 655ft radius with 63 deg bank; combat radius at sea level, 180 miles, including 5 min at rated thrust (static), take-off with reheat, cruise at sea level, 10 min at military power, 10 min loiter, return at best-range speed, and reserve of 5 per cent plus 20 min loiter; max. sea-level endurance, 3¼ hr; average speed for max. endurance, 186 m.p.h.; take-off, 920ft on ground, 1,260ft to 50ft; landing, 1,530ft from 50ft (915ft with tail braking parachute) or 990ft ground run (380 with braking chute); full-flap stalling speed, 90 m.p.h.; max. rate of climb at design gross, 4,830ft/min at 265 m.p.h.

The extreme nose section of the fuselage is made largely of a plastic laminate, reinforced with glass fibre, with a thickness of one inch. This was found to stop all but direct 90-deg hits from 0.5in or heavier weapons at point-blank range. For further protection, a ¼in-thick light-alloy plate is set beneath the instrument panel. The thicknesses of transparency are indicated on the drawing, and these were considered to offer complete protection against projectiles larger than 20 mm calibre striking head-on. The skinning of the whole nose capsule was to be in ¼in light alloy.

The capsule is attached to the rest of the aircraft by four explosive bolts. When these are sheared, all the pipes and wires connecting the capsule to the main fuselage are parted at quick disconnections, the flying controls having simple bell-cranks on both nacelle and fuselage which butt against each other (the same sort of arrangement was used on the Horsa II and is to be used on the Accountant). The parachute has a 60ft canopy, which restricts the let-down to about 25 ft/sec. The shock of


1 Reinforced plastic "bed," foam-rubber covered.
2 Windscreen, 3in. thick.
3 Forward sidescreens, 2in. thick.
4 Aft sidescreens, 1in thick.
5 Spectacle-type control column (see inset).
6 Nosewheel retracts rearward into wall between pilot's legs.
7 Nose-capsule break-line.
8 60ft-diameter parachute for nose-capsule.
9 Fuel tanks.
10 Port engine air intake.
11 Twin side-firing guns.
12 Single forward-firing gun.
13 Eight 5in rockets (or four rocket clusters).
14 Slotted flap.
15 Port engine tailpipe.
AILERONS
ELEVATOR
RUDDER

MARTIN MIDGET . . .

landing is minimized for the pilot by the foam-rubber bed and a chin-rest, the latter being extended automatically upon jettisoning the capsule. After landing, the capsule serves as an armoured shelter, and it carries small arms, first-aid supplies and food.

The airframe was designed for 12g loading with a factor of safety of 1.5, and it was considered that the radius of turn could be held to 580-600ft at all speeds between 175 and 345 m.p.h. Information available at the time the Midget was designed showed that, in ground-strafing, half the rounds fired by average pilots fell into a circle with a radius equal to about two per cent of the aircraft-to-target distance. The Midget was designed to be able to approach its targets closer than any other aircraft.

On the score of interchangeability, the Midget would show up well: among many interchangeable items are the port and starboard flaps, the port and starboard elevators, and—all three identical—the two ailerons and the rudder.

Gun armament could include two cannon of 15, 20 or 27 mm calibre, with 300 rounds per gun, or six rifle-calibre weapons each with 600 rounds. It was suggested that two pairs of rifle-calibre weapons should be mounted firing laterally above the wing (see drawing) which could be brought to bear during a sustained turn around a target; further, they could be applied to a target which at the moment of detection was close to the flight path.

The basic under-wing load was to consist of eight 5in rockets or four pods each housing 19 2.75in folding-fin rockets. If the Midget were operated from a reasonable runway, however, a great variety of stores totalling 2,000 lb could be carried.

AMERICAN ORDER-BOOK

DURING the last week of October, and immediately prior to the November 2nd Congressional elections, aeronautical purchases totalling $828m (£295m) were announced by the U.S. Department of Defense. The bulk of these orders were for the U.S. Navy, and several new types of aircraft are involved. The full list of orders for aircraft is given below; it is amplified by some notes on the newer types of aircraft concerned.

Chance Vought. *F8U-1* (£16m): a new, supersonic air-superiority day fighter for operation from Fleet carriers. Powered by a Pratt and Whitney J57 with afterburner, the F8U will be the first Chance Vought design to go into production since the company ceased to be a division of the United Aircraft Corporation. The F8U has an unusual design of fuselage, housing power plant, fuel, pilot and equipment; the wing is a razor-edged, variable-incidence surface.

Douglas. *AD-6 Skyraider* (£6m): possibly the last basic type of Skyraider to go into production (over 4,000 have been delivered), the AD-6 is a multi-purpose machine most of which are used as attack bombers with atomic capability. Some £150,000 has also been voted for AD-4 spares.

A3D-2 Skywarrior (£16m): a development of the A3D-1, the A3D-2 twin-jet carrier-based attack bomber is already in producion at El Segundo.

A4D-1 Skyhawk (£23.5m): transonic, carrier-based light attack aircraft, powered by a Sapphire, the A4D is going into production against this initial order.

B-66 and RB-66 (£31m and £14.5m): land-based developments of the A3D, the B-66 series are powered by Allison J71s. From the size of these orders the type will equip many combat bomber and recce. wings of the U.S.A.F. The B-66 is in production at Long Beach, and the RB-66 is to be built at Tulsa (where B-47s are made).

Grumman. *F9F-9 Tiger* (£56m): one of the most promising carrier-based fighter designs, the Tiger is supersonic on the level on the power of a single afterburning Sapphire. Several of its unusual features are visible in the photograph below. This contract was the largest placed for any single aircraft type.

UF-1 Albatross (£4.3m): a further contract for the widely-used amphibious rescue aircraft.

Hiller. *YH-32* (£188,000): first order for a small two-seat liaison helicopter, with a ramjet-driven rotor.

Lockheed. *P2V-7 Neptune* (£11.2m): illustrated last week (p.699), this is the latest Neptune, with tail-mounted magnetic detection gear, new canopy and nose and Westinghouse J34 jet pods under the wings.

T-33A (£2.5m): standard U.S.A.F. tandem-seat jet trainer.

T2V-1 (£5.6m): first production order (by the Navy) for the Lockheed trainer developed from the T-33. It has aerodynamic improvements to increase safety, a raised rear seat and a tail braking parachute.

Martin. *P5M-2 Marlin* (£4.3m): a revision of the largest twin-engined aircraft in service, a Turbo-Compound-powered patrol flying boat. Features are a large nose radome and a "T-tail" faired in with a second radome, possibly housing a magnetometer.

McDonnell. *AH-1* (£14m): this sum is allocated to development of the AH-1, an attack development of the F3H Demon supersonic carrier-based fighter.

North American. *FJ-3 Fury* (£7.2m): a Sapphire-powered, carrier-based development of the Sabre.

FJ-4 Fury (£6.6m): illustrated above, this is a further development of the "navalized" Sabre (also see p.743).

Sikorsky. *HR2S-1* (£17.3m): the first production order for the S-56 twin-engined assault transport 26-seat helicopter (Marine Corps).

H-37 (£22.9m): the Army version of the S-56. The size of this order and that immediately above is noteworthy.

HSS-1 (£3.1m): first Navy order for a new single-engined anti-submarine helicopter.

The FJ-4 is seen here on its first take off from North American's Columbus factory. Differences from earlier Furies are listed on p. 743.

First prototype of the Grumman F9F-9 Tiger. Later prototypes are now beginning to appear, with very slight differences. This particular aicraft suffered a "flame-out" at 8,000 ft., failed to reach the Grumman airfield at Peconic River, and was written off.

SUBSONIC RAMJETS for HELICOPTERS

An Examination of the Possibilities

By P. R. PAYNE

POSSIBLY the greatest disadvantage of contemporary helicopters is their mechanical complexity, which apart from increasing maintenance costs has a very powerful effect on first cost. This is well illustrated by comparing a typical four-seat fixed-wing aircraft and four-seat helicopter:—

Approximate first cost of helicopter	£35,000
Approximate first cost of fixed-wing aircraft ...	£2,500
Cost of ability to hover	£32,500

Thus the helicopter imposes an initial burden of over £10,000 per passenger. In his lecture[1] to the Helicopter Association last year Commandant H. Boris said that the annual utilization of the helicopters flown by his company (Helicop-Air, who are Hiller's representatives in Europe) did not exceed 500 hr. On this figure it is evident that each passenger has to pay heavily for the ability to hover.

In his lecture Cmdt. Boris compared the Hiller Hornet ramjet helicopter with the conventional 360 from the point of view of an operator, and concluded that, at a first cost of £3,500, the Hornet would reduce present operating costs by 40 per cent. This is a remarkable reduction, particularly since the ramjet engines powering the Hornet are relatively inefficient, owing to the low Mach number at which they operate.

Ideally, a helicopter with tip-mounted power units is a rotor system from which is suspended the pilot's control, a fuel pipe, and some means of supporting the pilot and payload. The reduction in complexity is indicated by the first costs of the Hiller Hornet and 360, roughly £3,500 and £13,000; and the reduction in maintenance costs should be even more marked.

It is obvious that a case exists for the ramjet helicopter: the difficulty is to find a reliable method of determining the strength of its case relative to other forms of propulsion, and then to select realistic values for the comparison. A true comparison of efficiency could be made only by completely designing and building a range of helicopters equipped with the different types of power unit to be compared, and then reviewing their behaviour during several years of operational service. Even then a true comparison could be obtained only by ensuring that the different design-teams were all of the same average ability. In practice it is usual to assess different systems on the basis of performance alone, and the easiest way of so doing is to calculate the variation of total engine-plus-fuel weight for the required operational flight time. Even this cannot be done exactly, and such studies as have been published often show a strong bias to the products of the authors' companies! This is because so many factors have to be "estimated" and it is only human nature to be optimistic about one's own work, and perhaps a little pessimistic about the efforts of others.

The nearest approach to an impartial survey is possibly the recent lecture[2] read by Mr. J. Brown before the Helicopter Association, in which he assessed the various propulsive systems which are currently being developed for helicopters. Fig. 1 is derived from the results presented by Mr. Brown for a 10,000 lb a.u.w. machine, except that his weight estimate for the transmission of a shaft drive helicopter has been reduced by 120 lb. Additional curves have been included for subsonic and supersonic ramjets, so that there is here a danger of the writer exercising his optimism to bias the picture in favour of the ramjet! All that can be said to justify the figures is that they are conservative in the case of the subsonic unit and very conservative for the supersonic case, the fuel consumption being identical with the Marquardt figures given by Harned[3]. Full allowance has been made for the special problems of rotation.

It is evident from Fig. 1 that for a large helicopter the subsonic ramjet is superior to other currently operating systems up to durations of about 40 min. This has already been well established by other investigators. For durations of between 40 and 55 min the ducted-air scheme, with tip burning at 1,230 deg C, is most efficient; and for greater durations the shaft drive system is the best of current techniques. The supersonic ramjet/rotor combination, which is shown to be superior to all these systems (Fig. 1 and Table I) up to over three hours, will be dealt with in a further article.

TABLE I

Flight Duration (hr)	Optimum Power Unit (present techniques)	Optimum Power Unit (supersonic rotor)
0-0.65	Subsonic ramjet	Supersonic rotor and ramjet
0.65-0.9	Ducted air with tip burning at 1,500°K	
0.9-3.3	Shaft drive (turbine)	Shaft drive
Over 3.3	Shaft drive (turbine)	

NOTE: All-up weight assumed at 10,000 lb.

In addition to the reservations so far made there are two main objections to a study such as Fig. 1: it does not take into account aircraft size or mechanical complexity. On the first count, and to take an extreme example, it is obvious that ducted air with tip burning would be less attractive on a single seat ultra-light machine than would ramjets. Mechanical complexity is simple enough to estimate in general terms, but its impact on the economics of operation will always be, to some extent, a matter for argument. Bearing these points in mind, Table II presents the writer's opinion of the optimum power units for operation in small helicopters up to and including the four/five-seater category. It is inevitable that those concerned with other types of power unit will disagree with the choice, but it is probably fairly close to that which would be obtained if a Gallup Poll could be conducted in the helicopter industry as a whole. A duration in excess of three hours is rather academic for this class of aircraft, so that the piston engine does not appear very attractive for general use. In any case it is to be hoped that the manufacturers of small gas turbines will be able to reduce—even to halve—specific fuel consumptions.

TABLE II

Flight Duration (hr)	Optimum Power Unit (present techniques)
0-1.5	Subsonic ramjet
1.5-3.0	Shaft drive
Over 3	Efficient piston engine

Before concluding this brief assessment of the subsonic ramjet it is essential to consider the pulsejet, for which many claims have been made. Table III presents the best available figures for specific fuel-consumption, and it is evident that a pulsejet helicopter would require about twice the fuel load of a ramjet type. The fundamental reason for this is the difference in tip speeds: the pulsejet tip speed is 360 ft/sec whilst the ($M_o = 0.8$) ramjet travels at 900 ft/sec. Thus one pound of ramjet thrust does over twice the work of one pound of pulsejet thrust.

The reason for this difference in tip speeds is partly that the pulsejet operates most efficiently at speeds of around 300–400 ft/sec, above which the thrust drops off very rapidly, whilst ramjet efficiency continues to rise with tip speed until a Mach number of about 3.0 is reached. The main reason, however, is a mechanical one and concerns the high centrifugal forces which are experienced at the tip of a rotor blade, where the acceleration can be as high as 2,000g. The pulsejet has a long, hot tailpipe (around 900 deg C) which is being subjected to violent pressure fluctuations at a frequency of the order of 100 c.p.s. Even if the difficult task of making the pipe statically strong enough to resist the centrifugal bending is achieved, there are still the problems of fatigue and creep to be faced. Thus the maximum acceleration which the unit can stand is of the order of 250g, as shown in Fig. 2. It is believed that in an effort to combat this limitation American Helicopters have tried

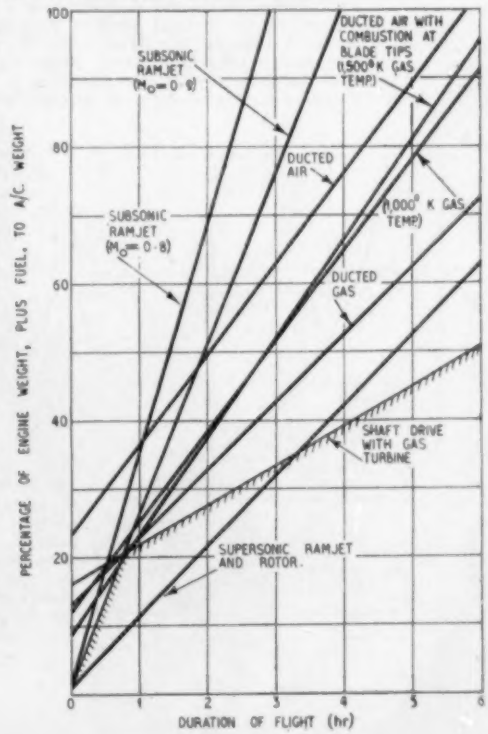


Fig. 1. Relative efficiency of propulsive systems for a helicopter of about 10,000 lb all-up weight.

SUBSONIC RAMJETS FOR HELICOPTERS . . .

manufacturing pulsejet pipes from ceramic-coated titanium.

The ramjet does not suffer from this limitation at all, since it can be designed in such a manner that the tailpipe skins carry no bending loads, but only direct tensile loading.

The variation of fuel consumption with acceleration is shown in Fig. 2. Rotor thrust is proportional to rotor h.p. in the design case, so that the effective specific fuel consumption on this count is 50 per cent greater than for the ramjet.

A second and less obvious source of pulsejet structural failures is illustrated by Fig. 3. The internal pressure is fluctuating from a maximum value, tending to keep the pipe circular, to a minimum value which tends to flatten it, whilst the more powerful centrifugal forces tend to flatten it the whole time. Even without the centrifugal component this limits the static fatigue life to about 70 hours, so that the life of a helicopte: unit would presumably be much smaller. Thus the reduction of tailpipe length by increase of operating frequency, whilst it will alleviate the first problem, may accentuate the second.

With the subsonic ramjet the internal pressure shown in Fig. 3 is steady, and varies from unit value at full thrust to about 75 per cent of this value when the flame is extinguished. Thus the cross-sectional shape can be allowed to deform (on the drawing board!) until the internal pressure at full thrust balances the centrifugal forces, and there is only direct tension in the skin. This was first done by McDonnells in the U.S.A.

Below maximum thrust there will be some bending in the skins, which can either be reacted, since the skin is cooler, or the skin can be so constructed that it will deform to the new equilibrium shape. Skin temperature is a function of tailpipe length, and by so designing the pipe that the fuel near the skin is burnt just prior to reaching the nozzle, the temperature can be kept quite low. It is unusual for temperatures above 500 deg C to be reached on helicopter units, so that creep and fatigue life is measured in thousands of hours.

The last point in this short comparison is that of noise. Despite the length of time the Hiller Hornet and other subsonic ramjets have been in existence, there is still a general feeling that ramjets are noisy. Power for power, a helicopter ramjet is quieter than the conventional piston engine, and, provided that combustion is complete before the nozzle is reached, probably quieter than the gas turbine power-plants which will be used in the future. A pulsejet, on the other hand, is extremely noisy. Powell[1] gives a figure of 22 Watts of acoustic energy per pound of thrust for a Saunders-Roe pulsejet. This is extremely noisy, and must impair the efficiency of personnel subjected to it.

Proceeding now to the design features of a helicopter ramjet, the general principle of its operation can be seen by considering an idealized duct, first postulated by the German worker Pabst (Fig. 4). If we neglect skin friction the argument runs as follows: With no combustion inside the unit there is no thrust or drag, so that $V_o = V_i = V_e$. Adding heat to the internal air by burning fuel increases the internal pressure so that the air entering is slowed down, and V_i is less than V_o. Since V_e will not be reduced by the internal pressure V_e is greater than V_o and the ramjet is subjected to a thrust force, which must be the resultant of pressures over its surface. Being a cylinder parallel to the flow, the inner duct cannot contribute to the thrust, which must therefore be the resultant of pressure over the outer fairing.

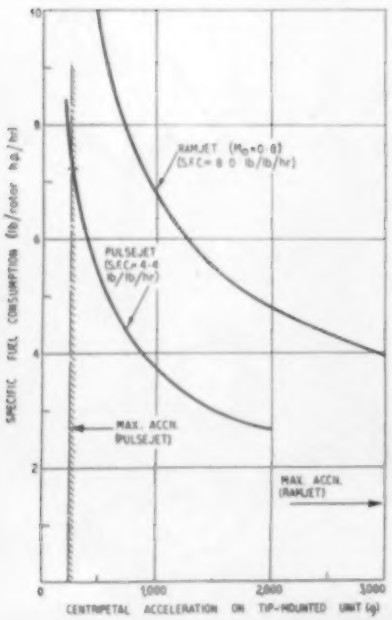

SPECIFIC FUEL CONSUMPTION (lb/rotor h.p./hr)
RAMJET (M₀=0.8) (S.F.C.=8.0 lb/lb/hr)
PULSEJET (S.F.C.=4.4 lb/lb/hr)
MAX. ACCN. PULSEJET)
MAX. ACCN. (RAMJET)
CENTRIPETAL ACCELERATION ON TIP-MOUNTED UNIT (g)

Fig. 2 (left). Typical variation of specific fuel consumption for light helicopter ramjet and pulsejet, tip mounted. Maximum acceleration permissible for the pulsejet will vary slightly with tailpipe length; in the ramjet it will vary slightly with frontal area.

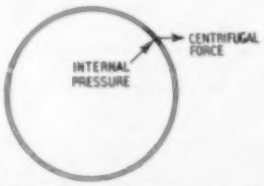


Fig. 3. Forces acting on wall of tip unit.

TABLE III

Engine	Specific Fuel Cons. (lb/lb thrust/hr)	Specific Fuel Cons. (lb/rotor h.p./hr)
*Pulsejet (hovering) (measured)	4.4	6.7
†Pulsejet (flight) (after development)	6.6	10.1
Pulsejet (static) (Saunders-Roe)	2.2	3.5
Ramjet (M_0=0.8)	8.0	4.9
Ramjet (M_0=0.9)	6.5	3.6

NOTES: * Best American figures available. † 50 per cent increase in fuel consumption is due to yawed flow in forward flight (verbal information from American manufacturers).

The streamline separating inside and outside flow is shown in Fig. 4. The outside flow is obviously analogous to that over the leading edge and upper surface of an aerofoil at a moderately large angle of attack. Hence a high suction-peak over the nose will exist, and Pabst contends that this peak is primarily responsible for the thrust force. Despite the suction peak German tests have shown that free-stream diffusion along these lines is still efficient at Mach numbers as high as 0.8 or 0.9.

In most practical designs, however, part of the slowing-down process is carried out inside a conventional diffuser, as illustrated in Fig. 5. If we retain the Pabst conception, then this can be regarded as a method of increasing the thrust by

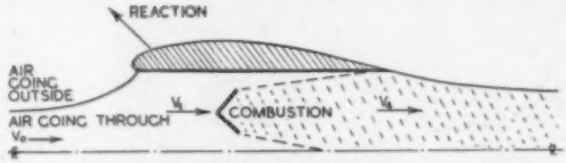


Fig. 4. Pabst idealized ramjet.

increasing the camber of the "aerofoil." Additional thrust now comes from pressures inside the diffuser. The tailpipe is also choked to some extent on subsonic designs, to increase efficiency, and the entry and exit areas of the Hiller Hornet ramjet give some idea of the expansion and contraction used:—

	sq in	% max. area
Intake area	11.05	26.8
Maximum area	41.30	100.0
Nozzle area	15.92	38.5

The satisfactory burning of fuel in the ramjet combustion chamber is probably the most difficult thing to achieve in a small subsonic ramjet. As Fig. 6 illustrates, the basic requisite is a bluff body or gutter which, by inducing turbulence, will stabilize the flame behind it. This stabilization is possible for only a limited range of fuel/air ratios, outside which it will "blow out." The weak blowout occurs at an air/fuel ratio of the order of 100/1 (by weight) whilst the rich blowout depends on the burner design. In many units rough running proceeds the rich blowout, which in any case occurs above the fuel/air ratio for maximum heat-release. Increasing the air velocity in the combustion chamber brings the stability limits closer together and renders ignition more difficult; good baffle design can widen the limits. The phrase "baffle design" is perhaps a mis-

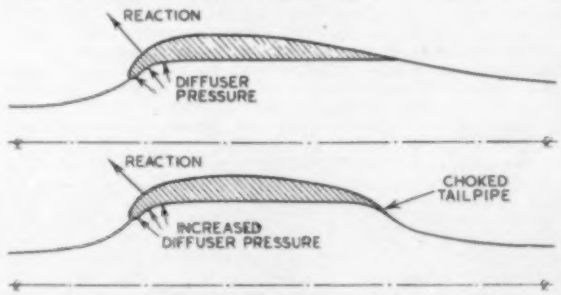
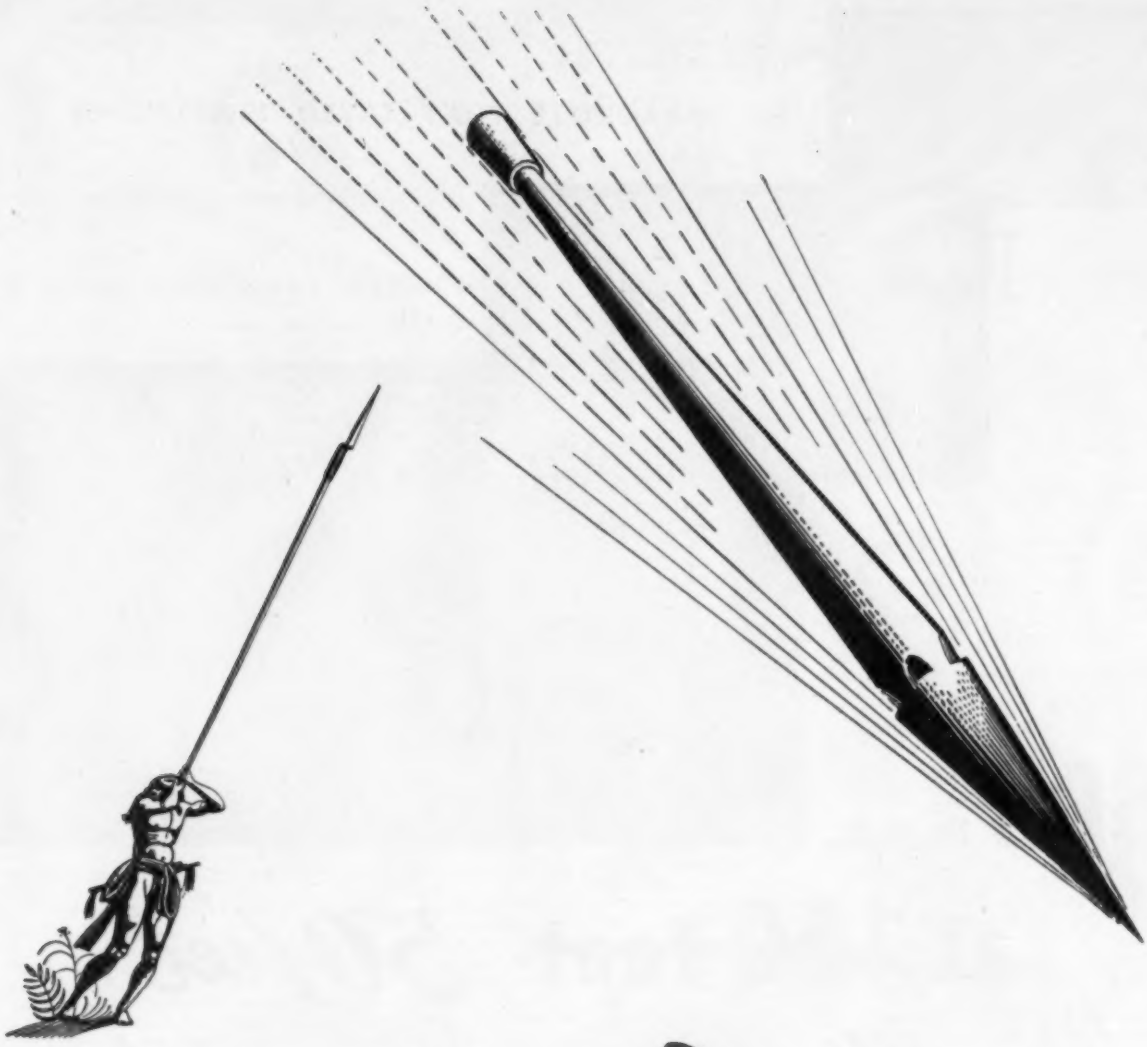


Fig. 5. Modifications to idealized shape.

nomer, since the best baffle can be found only by practical experiment, guided only by a few general considerations, all of which may be erroneous. In general, it is not possible to obtain more than a 70 per cent power variation from a ramjet, because of stability limits.

Combustion efficiency primarily depends on the size and distribution of the fuel droplets in the air before they reach the baffle, and on the efficiency of mixing the products of combustion after the baffle. As Fig. 6 indicates, the combustion as such may be excellent; but, if complete mixing does not take place



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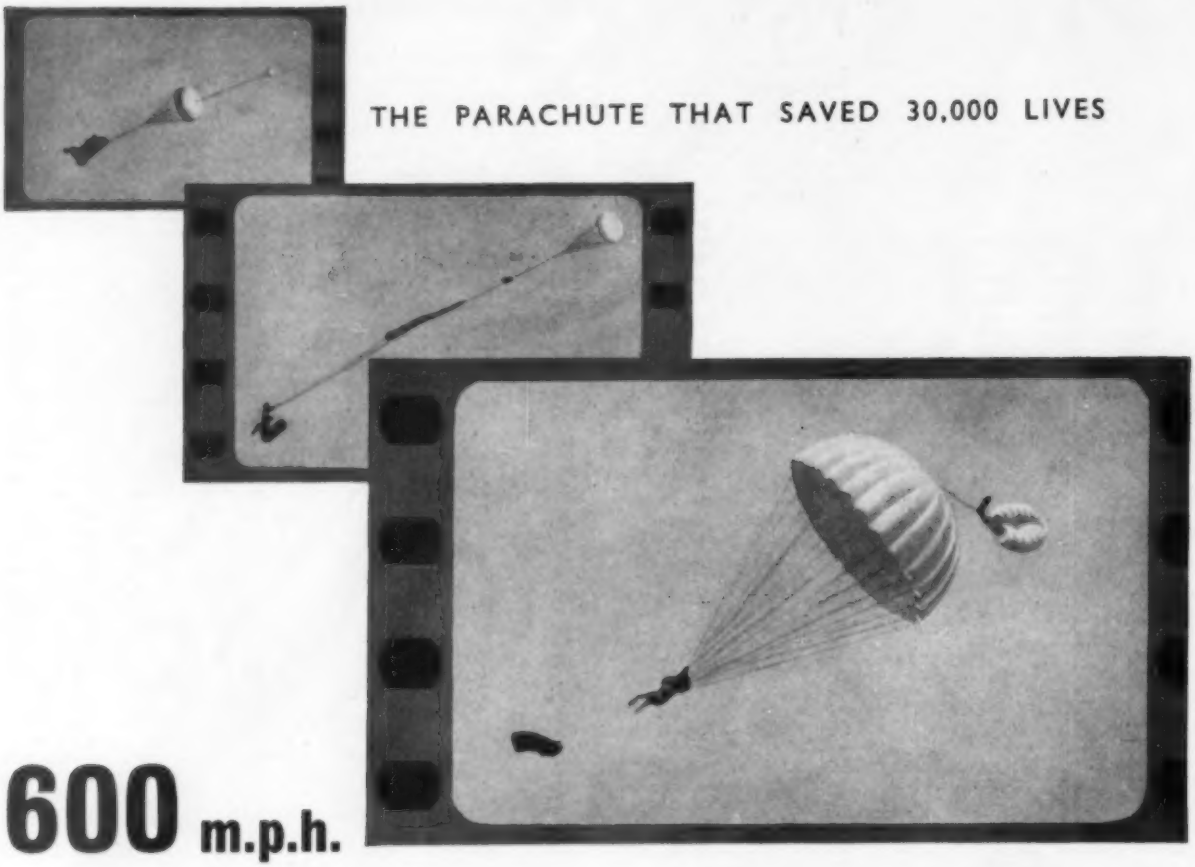

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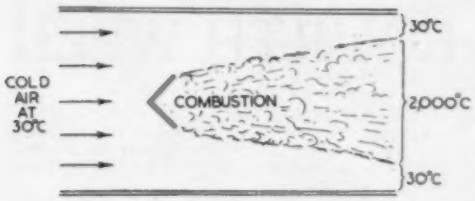

Fig. 6 (left). Incomplete mixing of combustion products.

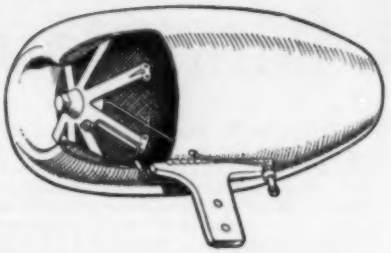

Fig. 7. Hiller Hornet ramjet unit in partial section.

SUBSONIC RAMJETS FOR HELICOPTERS . . .

before the nozzle is reached, a low overall efficiency is obtained. Fortunately the heavy choking needed on a subsonic ramjet for minimum fuel consumption materially assists this mixing, whilst the combustion length needed completely to burn a fuel droplet is minimized by the necessity for operation at low fuel/air ratios, again dictated by the need for fuel economy.

The fact that helicopter ramjets operate most efficiently around fuel/air ratios of 0.03 to 0.04 means that a large reserve of emergency power is available. In the event of one engine failing in cruise, for example, the power output of the other can be doubled to permit a return to base; and the use of this high power will have no adverse structural effects on the engine (since the skin temperature will be only slightly increased) or on the airframe, where the out-of-balance vibration will be barely perceptible.

Fuel injection is carried out through nozzles in front of the baffle, and the greater the number of nozzles the less the spray distortion by centripetal acceleration. The centrifugal pumping in the blade delivers the fuel to the tip at very high pressure in the range 2,000-4,000 lb/sq in. If these pressures are used to force the fuel through very small nozzles a magnificently divided spray is obtained, which is virtually unaffected by centripetal acceleration. This means that thrust control must then be effected by varying the pressure or the number of nozzles.

The alternative approach, used on the Hiller units, is to minimize centrifugal pumping by the use of restricting orifices in the blade fuel-line, and control fuel flow by varying the pressure at the root end of the blade. This gives a sluggish control, since there is a time-lag involved, and reduces the combustion efficiency (as explained above) by reason of the relatively coarse spray.

The Hiller engine is illustrated in Fig. 7. Points of interest are that the fuel is sprayed upstream so that the shearing action of the air will assist in reducing droplet size, and that use is made of radial finger-type flat-plate baffles, mounted well up into the diffuser. It is difficult to see why Hiller mounts the baffle in such a forward position, since the air velocity past it is still fairly high at the centre, thus closing the stability limits and increasing the internal drag. It may be that, with a circular ramjet, this compromise is essential in order to obtain reasonable combustion efficiency in an overall length of 18in—a limitation which is imposed partly by a desire to keep down control and blade torsional loads, but mainly by the circular section of the unit, which compels the shell to carry bending and shear, in addition to direct tension. As explained above, this type of construction will probably limit the Hiller type of engine to tip speeds of the order of 700 ft/sec.

Turning now to the application of subsonic ramjets to future helicopter projects we are on much less substantial ground. Harned says:[2] "The most promising application of all those in the subsonic field is that of the convertiplane. By using small high-speed rotors with tip ramjets for vertical ascent and propellers driven by rotating engines for forward motion, a high-speed convertiplane with good range could very simply be obtained. The value of such a craft for both military and civil application is very obvious. . . . The author predicts within a very few years the probability that the feederline transport will give way to the ramjet convertiplane with the elimination of airports for this type of service."

A more immediate application is indicated by Table II, where the inference that ramjets can be profitably used to power most light helicopters is made.

Referring to Fig. 1, we see that, on a pure performance basis, ramjets should be used for any large helicopter which has an average operational time of less than one hour per flight. If and when the Army receives the "flying cranes" we are told it needs, it is reasonable to assume that they will be ramjet-powered. Crop-spraying helicopters also come under this heading of short-duration flights.

Ramjets are not limited to petrol, of course, and can use any of the much cheaper paraffins. Theoretically they can run on most gaseous or liquid fuels, coal dust, and even solid coal if it is burnt in a suitable grate and is accurately shaped before use. In the distant future we may expect atomic ramjets to replace most other forms of jet engines, since the simple duct seems best able to cope with the rather severe limitations imposed by radioactive materials; but it is doubtful whether such engines could be used on rotors.

A more immediate subsonic development may be the intermittent ramjet[5] which makes use of pressure waves to increase the effective compression ratio intermittently, the pressure peaks coinciding with brief intermittent or variable combustion. The use of this cycle offers prospects of halving fuel consumption.

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(3) Malcolm Harned: *The Application of the Ramjet to Aircraft Propulsion.* Lecture to the American Society of Mechanical Engineers, December 1952.

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(5) J. V. Foa: *Single-flow Jet Engines—a Generalized Treatment.* Journal of the American Rocket Society, September 1951.

(Mr. Payne's article on supersonic ramjets will appear in an early issue.)

G/C. HOCKEY JOINS BLACKBURNS

A RECENT appointment announced by Blackburn and General Aircraft, Ltd., is that of G/C. R. C. Hockey, D.S.O., D.F.C., who is to be personal executive to Mr. Eric Turner, the managing director. G/C. Hockey was with Metropolitan-Vickers from 1928 to 1930 and at Imperial College from 1930 to 1934. In 1935 he was a technical officer at the R.A.E. and two years later was appointed Inspector of Accidents to the Air Ministry. Having joined the R.A.F. Reserve in 1935 he was mobilized at the outbreak of war and served as a flying instructor before transferring to No. 24 Sqn. In 1940 he joined the Special Duties Flight of Bomber Command and two years later commanded No. 138 Sqn. In the following year he formed No. 334 Wing, Mediterranean Allied Air Force, and later was posted to the Air Staff of H.Q. 38 Group. After the war he graduated at the Empire Test Pilots' School and was test flying at Boscombe Down before being appointed Head of the Department of Flight at the College of Aeronautics. His most recent post was as aviation divisional engineer to S. Smith and Sons, Ltd.

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COMET INQUIRY: THE FOURTH WEEK

UNDER the Rt. Hon. Lord Cohen (commissioner), with Sir William Farren, C.B., M.B.E., F.R.S., Professor W. J. Duncan, C.B.E., D.Sc., F.R.S., and A. Cdre. A. H. Wheeler, O.B.E., as assessors, the London inquiry into the accidents to Comets G-ALYP and G-ALYY entered its fourth week on November 8th. This section of this week's report describes the events of Monday, Tuesday and Wednesday of that week; subsequent evidence is reported on pages 731-2.

Monday, November 8th: Twelfth Day.—Mr. Walter Tye, chief technical officer of the Air Registration Board, continued to give evidence concerning the tests and strength factors required by the Board (and those accomplished by de Havillands) for pressure cabins, and his department's approach to the fatigue problem. Mr. Bruno Jablonsky, in his first official appearance before the Court, put forward his submission that the basic cause of the Calcutta, Elba and Naples accidents had been failure of Redux adhesive joints, caused partly by the Comet's high rates of climb and descent.

Mr. J. P. Graham, Q.C. (for the Crown), resuming his examination of Mr. Tye, referred to the A.R.B. requirements for proof strength tests of pressure cabins. To each production aircraft, Mr. Tye said, such a test, at 1.33 times the working pressure, or 11 lb/sq in, was applied. At the present time there remained no reference to any repeated-loading test in the Board's formal documents, although draft requirements to this effect had been proposed.

Describing the history of the Board's discussions on this subject, Mr. Tye mentioned a meeting in October 1949 at which the loss (from all reasons) of cabin pressure in high-flying civil aircraft was considered. A suggestion was then made by the R.A.E. that the ultimate strength factor, which in normal practice was 2.0 (the strict requirement being 1.5) should be increased to 2.5. The Board took this to mean that a designer should aim at 2.5 and test at 2, and proceeded with a draft requirement for 1.33 proof test and 2.0 ultimate. Mr. Tye agreed with Mr. Graham that de Havillands were ahead of requirement in that they did have an ultimate factor of 2.5 and that they tested the shortened pressure cabin to twice the working pressure.

In June 1953, the witness continued, the Board issued proposals, for subsequent discussion with manufacturers, for a repeated-loading test (15,000 applications of 1.25 times the working differential pressure) on pressure cabins, in addition to static tests. Mention was made of the probability that safe compliance with this would mean an increase of the ultimate factor, for certain areas, to 3.0. A comparison with the requirements of other bodies showed that the ultimate factor of 2.0 was also laid down in A.P.970 for military aircraft, in the U.S. Civil Air Regulations, and by I.C.A.O.

The early tests of the Comet design, Mr. Tye agreed, were broadly satisfactory, since the then-recently-prepared requirements were complied with. The ultimate factor of 2.0, he pointed out, was really a factor of caution, designed to contend with fatigue of the nuisance variety rather than the dangerous type. In December 1948 the Board discussed with de Havillands the airworthiness of a large number of features of the aircraft: at that time the company's tests were "fully up to current practice, perhaps a little in advance of current practice." The Board believed at that time that any cracks formed at normal working pressures would be non-catastrophic, and would be inspectable and repairable before reaching dangerously large dimensions—a belief based partly on R.A.E. tests.

Between 1950 and 1952, Mr. Tye went on, "we had begun to become much more deeply immersed in fatigue problems." These mainly concerned wings, but with them arose consideration of the importance of fatigue in pressure cabins. This was not felt to be a matter of urgency in the case of the Comet, because working-pressure stresses were believed to be about 40 per cent in the main shell, and to have been designed not to exceed 50 per cent of the ultimate. An average life of at least 10,000 applications of pressure (equivalent to 30,000 hr), and a corresponding minimum safe life of 10,000 hr, had been estimated.

The Calcutta accident did not alter the A.R.B. views on the soundness of the Comet pressure cabin, Mr. Tye said, as neither the general circumstances nor the examination of wreckage had suggested failure of the cabin. In the case of the Elba accident, such failure was at least a potential explanation, but it still seemed inconceivable that failure at one-third of the estimated safe life could occur. De Havilland tests on the Comet nose-section at this time had reached 18,000 applications of 8½ to 9 lb/sq in, which might have indicated a life of 54,000 hr. Pre-loading might have influenced this figure, but could not completely rule it out as an indication.

A careful inspection of Comet pressure cabins was nevertheless made: no fatigue indications were found, and it seemed that pressure-cabin failure could be discounted as a cause of the accident. As previously described, many modifications were made, after which the Board was satisfied that it was right that the Comet should fly again.

Cross-examined by Mr. J. M. Shaw (for the relatives of a number of the deceased crew-members and passengers), Mr. Tye said that normally the A.R.B. would not check the designers' stress calculations, and would assume them to be in order, although it would see the results of the calculations in summarized form. Although exact stress answers could be found for cases such as a round hole in a sheet, the presence of reinforcing structure around such a cut-out in an actual aircraft left more room for personal experience and opinion. In view of possible wide divergencies in calculation, therefore, strength tests were most valuable.

Although de Havilland calculations had indicated a maximum stress of 50 per cent ultimate, Mr. Shaw pointed out, the Farnborough tests had shown 70 per cent round the A.D.F. windows: was not this a large gap, and how could it arise? The witness agreed that he would have expected "something rather closer," but could not give an opinion on the reason for the difference.

Following a question by Mr. Shaw on the amount of strain-gauging done during the de Havilland tests, Mr. Rodger Winn (for the de Havilland company) stated: "So far as the strain-gauging is concerned, we concentrated on the windows of the pilot's part, namely, in the cockpit, but in the case of the other windows, with perhaps one or two exceptions, reliance was put upon calculation followed by empirical tests. . . ." Mr. Tye commented that the strength tests themselves would be an indication that the stresses were of a satisfactory order. Questioned finally by Mr. Shaw concerning manufacturers' concession notes relating to corrected defects, Mr. Tye said that an A.R.B. inspector would not see all such notes automatically: they were available for his inspection, and he would carry out spot checks at random, following up any that were not satisfactory.

The evidence of Mr. Bruno Jablonsky (who had previously written to the tribunal disagreeing with some of the conclusions in the R.A.E. report) was interposed at the start of the afternoon sitting. Examined for the Crown by Sir Lionel Heald, Mr. Jablonsky agreed that he had been taught to fly by Orville Wright, since when he had had a comprehensive background of aeronautical engineering and had become a specialist in laminated plastic materials. During World War 2 over 400,000 of his company's laminated airscrews had been produced, and since that time the firm had supplied jigs, tools and metal components for the Comet. The company had experimented with and had produced various types of synthetic resinous materials, and had experience with the products of Aero Research, Ltd., and the Ciba company.

Mr. Jablonsky said first that he would like to correct the statement made by Sir Lionel to the Court on an earlier day that he (witness) believed Sir Arnold Hall to be "all wrong." Witness agreed that the R.A.E. work formed an important advance in the study of metal fatigue: he further agreed with the Farnborough conclusions that the cause of the Elba accident was the bursting of the pressure cabin, due to an inherent weakness in that cabin. Concerning the fatigue explanation put forward by the R.A.E., Mr. Jablonsky accepted that fatigue might have been present, but thought that fatigue failure had probably occurred only after other contributory factors had caused the initial disruption. He believed that the cabin weakness could be overcome, providing performance limitations were accepted.

Temperature-change Effects

Mr. Jablonsky agreed that in his written statement outlining the "other contributory causes," he had referred to the Comet's "excessive rate of climb" and to the use of an adhesive instead of rivets. Sir Lionel submitted that the Comet's climb of 2,000 ft/min at sea level, decreasing to about 1,000 ft/min at 30,000ft, was not fast compared with, say, a Vampire or Hornet; and that the effect of changes of temperature on the adhesive bond (discussed at length in Mr. Jablonsky's written statement), if applicable, would be observed on these aircraft, too. The conditions were different and no comparison could be made, said Mr. Jablonsky. The case of a Dove aircraft which had flown about 16,000 hr was next cited by Sir Lionel: if there was any inherent defect in the adhesive bonding, would it not have shown up? "Not if its operating conditions were less severe than those of the Comets," the witness replied.

Expansion and contraction of the skin caused by the rapid change in temperature was the main factor in his "rate-of-climb" argument, Mr. Jablonsky agreed. He himself had made relevant laboratory tests, but for absolute test accuracy all appropriate in-flight conditions should be reproduced. Sir Lionel submitted that the 25,000 hr stated by Sir Victor Tait to have been flown by Comets was in itself a most impressive test; Mr. Jablonsky replied that any damage could not be seen, as the joints were all covered: the total of hours was impressive, but not convincing.

Sir Lionel Heald: Perhaps you would tell the Court what you would need to convince you?—There was such a similarity between these three accidents that one cannot fail to try to reach conclusions and endeavour to find the weakest possible spot. In comparing fatigue, which affects not only metal but other materials as well, I would think that the plastic glue-lines are more apt to fatigue than metal. The accidents happened under such similar conditions—in the first stages of the first climb after a very rapid change of temperatures—that naturally I, as somewhat of a specialist in plastic materials, would go into the question and see whether these materials are not likely to be weaker, more likely to be the cause of these accidents than metal. Metal is likely to show the cracks and the defects which, we have heard, develop gradually, whereas in plastic materials such failures cannot be easily seen; they reach a point when they break away, and that is the end of it, without showing any signs of gradual development.

The wreckage of YP at Farnborough had been inspected by the Court and by Mr. Jablonsky on October 26th, and questions were next put to the witness concerning the damage to the central portion of the cabin, stated in the R.A.E. report to have been caused by impact with the water. The evidence seen on particular sections, together with the large number of small pieces in that area, claimed Mr. Jablonsky, indicated that an internal explosion was more probable. In his opinion, an explosion due to the bursting of the skin was followed by the fracture in the A.D.F. window area, which was possibly due to the pilot falling on to the stick and the aircraft entering a steep dive. One piece of wreckage exhibited in Court showed riveted stringers

which had withstood the impact, and an adjacent glued one which had failed.

In glued skin/stringer construction, Mr. Jablonsky thought, irregularities in the thickness of application of the glue were unavoidable. He suspected that the accidents at Calcutta, Elba and Naples were all due to the same cause, the temperature difference between the ground and the height of the aircraft being the major factor. The glue-lines on the aircraft, Mr. Jablonsky explained, consisted of a plastic material which lost its adhesive strength by as much as 50 per cent when exposed to heat. When the aircraft stood on its undercarriage on the ground in conditions of tropical heat, certain loads would have an influence on the structure, and might easily cause a lifting of the skin from the stringers—the beginning of a latent defect. "With circumstances as, in my opinion, they have simultaneously arisen in the two Mediterranean accidents, they have caused the small rupture in the glue-line to continue and to extend to such an extent that the unstable skin became loose and started buckling; and buckling is, of course, the beginning of collapse."

Sir Lionel stated that de Havillands were aware of the loss of strength of the glue under tropical conditions; the company's tests, however, had shown the reserve of strength to be ample. Mr. Jablonsky emphasized that in his opinion the metal surfaces might move, under the static loads mentioned, while the glue was soft, and thus cause latent defects, but went on to agree that testing was better than *a priori* reasoning alone.

Mr. Jablonsky was next cross-examined concerning his knowledge of the Redux process by Mr. J. Whitford (for Aero Research, Ltd.), who mentioned that there were at least 47 types of aircraft which at present used Redux for skin/stringer joints. The two effects that had to be considered in the case of pressure cabins, Mr. Jablonsky agreed, were those of temperature and of differential pressure. The two types of forces to be considered were the peeling force and the shear, the former being the most critical in the case of glued joints. Amongst points raised by Mr. Jablonsky in the subsequent discussion was the statement that while laboratory-made glued joints could be perfect, control of pressure and temperature in mass manufacture was less exact, and the glue-lines therefore might not be uniform.

In answer to Mr. R. A. MacCrindle (for the British Air Line Pilots Association), Mr. Jablonsky suggested that a remedy might be to use a combination of wide-pitched rivets and glue for skin/stringer attachment. Mr. Rodger Winn (for de Havillands) mentioned that in de Havilland tests over a range from −50 deg C to +60 deg C, no deterioration in Redux bonded joints had been apparent up to 10,000 reversals of temperature. The average strength in shear of their stringer test-pieces on the Redux joint was 3,000 lb/sq in. Compared with the 20 deg C value, the strengths at 40, 60 and 80 deg C were 86, 72 and 56 per cent respectively. The actual change in cabin diameter on ascending to 30,000ft, Mr. Winn claimed, was only 0.02in. (Temperature effect, −0.16in; pressure effect, +0.18in.)

Tuesday, November 9th: Thirteenth Day.—Continued cross-examination of Mr. Walter Tye by various counsel took place. Mr. Tye said that he had some doubts whether the Elba accident was due to fatigue, as concluded in the R.A.E. report, although he could offer no satisfactory alternative.

After questioning by Mr. Shaw concerning the manufacturing cracks found in Comet YP, Mr. Tye commented on his present understanding of their significance: "I think it is clear that even though the case may not be wholly proved about the dangers of manufacturing cracks, it is also clear that the commonsense way is to pay more attention than has been done in the past, that is, more attention by the Board. . . ."

The point was next made that fatigue was found only at one place in YP.

Mr. Shaw: Are you satisfied that fatigue was the cause of that crack from that slight evidence, or have you doubts about it?—I have doubts whether, looking at the extremely small fracture, one can deduce this new term "high-level fatigue" from that extremely small piece of metal.

What other theories are you suggesting as the cause of the disruption if it was not fatigue?—I have no specific theories to suggest as an alternative. Broadly, the disruption of the cabin, which I accept in full, must have arisen, as was pointed out very early in the proceedings, either from weakening of the structure to such a point that ordinary working pressure loads were able to cause disruption (and weakening almost certainly, in my mind, would be associated with fatigue rather than with other methods of weakening) or because the internal pressure became abnormally high, or the external loads became abnormally high, or possibly a combination of those last two, with weakening of the cabin itself. I have no specific suggestion to make as to how the working pressure could become abnormally high. Indeed, I have thought a great deal in trying to find such possible alternative ways of explaining the disruption. So that my answer is a somewhat unhappy one, in the sense that I am saying that I am not very enthusiastic about the conclusion, from looking at a particular specimen, that fatigue was present. On the other hand, I cannot produce any shattering alternative.

As regards the failure of YU in the Farnborough tank test, Mr. Tye said: "I am clear that it must have been fatigue which caused the disruption in the tank." Questioned further about the manufacturing crack in the forward port corner of the rear A.D.F. window, Mr. Tye said he doubted whether it had any great significance: no signs of fatigue had been found there.

Mr. E. J. Rimmer, Q.C. (for B.O.A.C.), in cross-examination, referred to the co-operation between the A.R.B., B.O.A.C. and de Havillands in the work of the Abell committee after the Elba accident, and in the agreement on the modifications to be adopted then. "In the process of the discussion of the theoretically possible accident causes," Mr. Tye stated, "it was feasible to eliminate some, having regard to the design of the aeroplane, as being virtually impossible. That left over a number of causes which were apparently not at all likely, but nevertheless sufficiently within the realms of possibility to warrant improving modifications of one kind or another. Therefore, at the end of that process, when all those improving modifications had been embodied, it was reasonable to hope that one or other of the modifications would sufficiently have improved the particular feature of the aeroplane that the cause of the accident had in fact been eliminated. It was hoped that that had been done." A comprehensive examination of YU and YY was carried out; although YY was not inspected for Redux failures, all associated modifications were incorporated before the machine recommenced service.

In reply to Mr. MacCrindle, Mr. Tye said that the A.R.B. chief test pilot agreed with the previously reported opinions of the R.A.E. pilots and a number of B.O.A.C. pilots that the power-operated control system of the Comet would be improved if it gave a more conventional "feel."

The A.R.B. had been satisfied as to the stresses in the Comet cabin, Mr. Tye continued, partly because proof and ultimate tests (for one minute and three seconds respectively) had been satisfied, and partly because information on calculations and strain-gauge readings had been provided. The proposed policy of the American airworthiness authorities had read "When the maximum airplane flight altitude selected for certification exceeds 25,000ft, typical window, emergency exits and door installations should be capable of withstanding, without failure, repeated load tests in which at least 10,000 applications of pressure differential are applied." The emphasis here was on the danger of doors and windows blowing out, rather than failure of the cabin shell itself, Mr. Tye pointed out, and de Havillands had in fact done more than these requirements proposed.

Future Test Requirements

Mr. MacCrindle: In the future, when you are deciding whether or not to recommend the granting of a Certificate of Airworthiness to a pressurized aircraft, would you personally like to see one of each kind of such aircraft put into the tank, as Yoke Uncle was at Farnborough?—For the immediate future, yes, that is to say, while we are finding things out, I think that it is absolutely essential for aircraft to be tested in the same way that YU was tested. I hope, thinking rather further ahead, that it will not be a continuing necessity in this respect. The development of aeroplanes generally proceeds along the line of building a few of one particular mark and then improving it and producing a second mark and a third mark. If each time some relatively small change is put into being, such as a slight lengthening of the cabin, or an extra door or extra window—if on each such occasion it is necessary to do extremely expensive tests, then, of course, it is a deterrent to improving the breed of a particular aeroplane by ordinary development processes; so I hope myself that, having learned sufficient, we may get back to the state of affairs which apparently exists in American aeroplanes, one of which was referred to the other day . . . capable of cracking for 24in and then coming down safely. Ideally, one would like to get to a state of affairs where an aeroplane can crack safely.

Concerning the manufacturing crack (not covered by a concession note) found in the skin at one corner of the rear A.D.F. aerial window, Mr. Tye told Mr. T. Humphrey Tilling (for the Navigators and Engineer Officers Union) that even before the Elba accident he would have considered this a bad thing: "I think we should have certainly sought a more complete examination of the aeroplanes in these regions, and perhaps a more complete repair to the particular part." Further questions concerned the discrepancy between de Havilland's tests and calculations, and those of the R.A.E.

Mr. Rodger Winn (for de Havillands) questioned the witness concerning his association with the tests and calculations on the Comet performed by the de Havilland company. The company, Mr. Winn stated, used strain-gauges only to give warning of imminent failure under test and not to measure the stresses round the fuselage cut-outs. Strain-gauges, Mr. Tye agreed, did not indicate any original locked-in stress. Mr. Winn next suggested that, while the de Havilland personnel with whom the A.R.B. had come in contact were reliable and conscientious men, they might have committed errors of judgment, and in particular there might have been an error of judgment on the part of the head of the Concession Department. Mr. Tye agreed.

After referring to the development of A.R.B. knowledge of fatigue, and to American C.A.A. pressure-cabin testing requirements (which, it was pointed out, were not ahead of current British practice), Mr. Winn said: "An impression has undoubtedly got abroad that the American airworthiness authorities in some way or other turned down the Comet III—ruled that it was unsatisfactory in some respects, having regard to their requirements or proposed requirements. Is there any foundation for any such impression, to your knowledge? Mr. Tye replied "None at all," and went on to emphasize that no airworthiness certificate was ever applied for; "The aeroplane we were discussing was not designed in detail, so that there was no question of rejection or acceptance." Subsequent questions included many referring to the problems of stressing around cut-outs.

Questioning Mr. Tye on the history of A.R.B. decisions before and after the Naples accident, Mr. L. G. Scarman (for the A.R.B.) quoted a letter sent after the accident from the Board to the Minister of Transport and Civil Aviation. Part of this read: "The Board cannot disregard the real possibility that there is some factor influencing the airworthiness of Comet aircraft which the most diligent investigations have failed to discover. Until such time as a satisfactory explanation is available, the Board recommends that Comet Certificates of Airworthiness should be withdrawn."

Mr. Scarman went on to suggest that a manufacturing company's satisfying the conditions for A.R.B. approval was itself a basic airworthiness requirement. The Board's staff, Mr. Tye agreed, had no facilities nor undertakings for research. Among the research establishments consulted was the R.A.E., with whom close contact had been maintained concerning fatigue and other matters. A communication from Farnborough to the Board in December 1949, referring to tests made "to see whether the development of cracks in a pressure-cabin

COMET INQUIRY: THE FOURTH WEEK . . .

skin would lead to disastrous failure," had stated that the results were "encouraging."

Referring to the six deviations from the Board's requirements which had been accepted when the Comet was certified, Mr. Tye agreed that this was not unusual; six was an average number of deviations.

The final part of Mr. Tye's evidence concerned the discussion of stress concentrations around rivet holes and larger cut-outs, about which Sir William Farren had questioned him the previous day. In the case of the Comet, Mr. Tye thought the effect of the presence of the first row of rivets "inland" in concentrating stress locally might well have been a more critical feature than the extreme edge stress. He personally was surprised at the close apparent correspondence between the behaviour of a metal around a rivet hole and around a large cut-out such as a window.

Mr. Tye agreed that, comparing graphs in the R.A.E. report with one in Dr. Williams' 1946 paper on fatigue, the limiting stress at which fatigue failure occurred on a test specimen with a single hole was much below that for the virgin metal, but not so low as would be expected from a consideration of the pure stress-concentration factor. The actual S/N curve for riveted joints gave stress levels lower than those to be expected from calculations, using the stress-concentration factor of, say, 2.4, due presumably to plastic-flow effects. The reason that the stress was not increased to the expected extent at high loads, Sir William suggested, was that the theory implied an elastic material throughout, while the material would actually cease to be so when the stress locally reached something like the material's elastic limit.

As the theoretical analysis did not take into account the presence of frames or other reinforcing structure, Sir William and Mr. Tye agreed, testing—and in particular, repeated-loading tests—would be required.

Wednesday, November 10th: Fourteenth Day.—After Mr. Tye had completed his evidence, the first two witnesses to be called by the de Havilland company testified. First, Professor A. J. Murphy described the metallurgical background to the material used in the Comet pressure cabin, and his deductions from an examination of parts of the wreckage, and then Mr. R. H. Harper gave details of the de Havilland company's stressing and test work on the Comet.

Continuing his cross-examination of Mr. Tye, Mr. Scarman inquired whether, in January 1952, the A.R.B. had shared the R.A.E. view that pressure-cabin cracks, if they spread, would not be dangerous. Mr. Tye agreed, and said that it was thought also that fatigue cracks would be observable. By 1953 work on fatigue was intensifying: an M.o.S. committee was formed to review fatigue knowledge relating to individual aircraft, and, earlier, an active interest in the subject was being taken by the Royal Aeronautical Society. After the Elba accident, as mentioned previously, the de Havilland tests had reached 18,000 reversals, and a safe life of 10,000 hr was felt to be reasonable.

Questioned further as to why he had lost confidence in the R.A.E. theory that fatigue was the cause of the accident to YP, Mr. Tye repeated that failure at the minimum safe life was most improbable. He found difficulty, therefore, from the YU tank test alone, in saying that a low fatigue life was probable. He agreed that a further intensive study of fatigue was demanded for the future.

In reply to questions from Lord Cohen, Mr. Tye gave his opinion that strain-gauges should be used to check early stress calculations. Again he could not offer a satisfactory alternative to the fatigue theory as the cause of the Elba accident; if the 9,000-hr figure obtained from the tank test could be shown to be *above* average, however, his misgivings concerning fatigue as the cause would disappear.

The next witness was Professor A. J. Murphy, Director of the Department of Metallurgy, Birmingham University, who had been called in by de Havillands for the Inquiry. Examined for the Crown by Sir Lionel Heald, Professor Murphy outlined the development of light alloys, and told how, knowing a material's intrinsic strength, the load and dimensions, accurate calculations could be made. Close control during manufacture ensured the reliability of the modern alloys.

The improved tensile strength of some light alloys, Professor Murphy said, was not accompanied by a corresponding improvement in fatigue strength: one of the best combinations of properties was, however, given in specification D.T.D. 546, as used in the Comet pressure-cabin.

The witness agreed more positively than Sir Arnold Hall with the R.A.E. conclusion that the failure at the rear starboard corner of the rear A.D.F. aerial window was due to fatigue. Examination of this corner had shown the shading, smoothness and fine grain which were typical of fatigue fractures: in the witness's opinion it originated at the countersunk bolt-hole.

Cross-examined by Mr. Scarman (for the A.R.B.), Professor Murphy agreed that the tolerance in the composition of D.T.D. 546 could cause a difference in the fatigue life of a specimen. Minimum fatigue properties would need to be ensured. If, to obtain a satisfactory fatigue life in Comet pressure-cabins in the future, a thicker skin was proved necessary, this would increase the static strength of the cabin. It might then be possible to use D.T.D. 610 (Duralumin, without the artificial ageing process which for D.T.D.546 raises its tensile strength).

In reply to Mr. Shaw, Professor Murphy said he agreed with Mr. Tye's figure of a safe life for the Comet of about 10,000 hr, based on de Havilland figures and test results quoted in the R.A.E. report. He felt however that the R.A.E. extrapolation to 70 per cent of ultimate at the edge of the A.D.F. window was open to doubt, since the last measured point was near a rivet hole and the stress level there would therefore have been affected. Stress-raisers such as the bolt-hole which he believed was the origin of failure were not sufficient in themselves to cause failure: their stress-concentrating effect must have been imposed on a high general level of stress. Asked whether he would have expected YU to fail at the same point, Professor Murphy said that, as there were higher stresses in the fuselage than static tests had shown, any one of a number of otherwise trifling features would cause a fatigue failure.

As high-level fatigue was difficult to identify, Mr. Shaw suggested, might not failure have taken place at the forward port corner of the rear A.D.F. window? Professor Murphy repeated that he thought it highly probable that the failure started in the starboard rear corner, but the opposite corner was a possible source as two types of development were seen there. Irregularities such as bolt holes and rivet holes could be coped with, the witness thought, provided the general stress level was brought down.

Answering Mr. MacCrindle, Professor Murphy stated that no account was taken of periodic temperature changes in studying the behaviour of the metal, but that the stress could be calculated fairly well. There was no damaging residual effect.

As a strain-gauge could not be placed right on top of a hole, submitted Mr. Tilling, the highest stress reading could not be obtained by direct measurement: somewhere in that area there would be a stress higher than that measured. Professor Murphy agreed with this.

An indication that the fracture at the port forward corner of the rear A.D.F. window was a tensile failure and not due to fatigue was described by Professor Murphy to Mr. Rodger Winn (for de Havillands). The thin film of aluminium, or cladding, which coated the material, was more ductile than the core, and might be seen to be drawn out in the case of a tensile failure, though not in the case of fatigue. On this basis it appeared that the port-corner failure was *not* due to fatigue. American tests in 1950, the witness claimed, had given a figure of 1.3 rather than the theoretical 2.4 as the stress concentration factor due to a drilled hole.

Sir William Farren pointed out that Dr. Williams' 1946 paper on fatigue, had, however, agreed with the 2.4 figure.

Mr. R. H. Harper, chief structural engineer of the de Havilland Aircraft Company, was the next witness. Examined for the Crown by Mr. J. P. Graham, he said that, in 1946-48, the pressure-cabin problem was being looked at as a static one. It was decided to strength-test representative portions of the Comet pressure cabin to a factor of 2.0, and so work to an ultimate factor of 2.5.

Consideration of Wing Fatigue

After reports of certain aircraft accidents had been published, the company became more conscious of fatigue: its main danger, however, was felt to be in the wings and not the fuselage. A letter from Dr. Walker of R.A.E. to the Director of Research and Development at the M.o.S., concerning tests on the Comet wing, had stated:—

"The fatigue situation gives rise to some concern. We estimate that the original design would have a life between one-fortieth and one-twentieth of what we normally require and usually obtain. Three joints are known to be seriously under strength in fatigue, but not, so far as can be judged, beyond remedial action. Two have in fact been modified by the firm and are probably now completely satisfactory, but the third modification has still to be done. Confirmatory tests on specimens of these three joints will, however, be necessary and should preferably be made at R.A.E. Action on this is already proceeding . . .

"We are not seriously concerned about the static strength and do not recommend a further static test. Premature failure at 85 per cent is attributed to weakening produced in the preceding fatigue test. It is considered sufficient that the firm put beyond suspicion the three weak places and this should not be difficult. If the structure successfully passes the overall fatigue test recommended, moreover, the case for accepting the static strength is made still stronger. We would record that in no circumstances could we agree to static and fatigue tests being planned for the same specimen. In this matter the firm have been most co-operative, but we should make clear that they have not been consulted in the preparation of the substance of this particular letter. We are sending them a copy and suggest that it might form the basis for the joint discussion which you are trying to arrange."

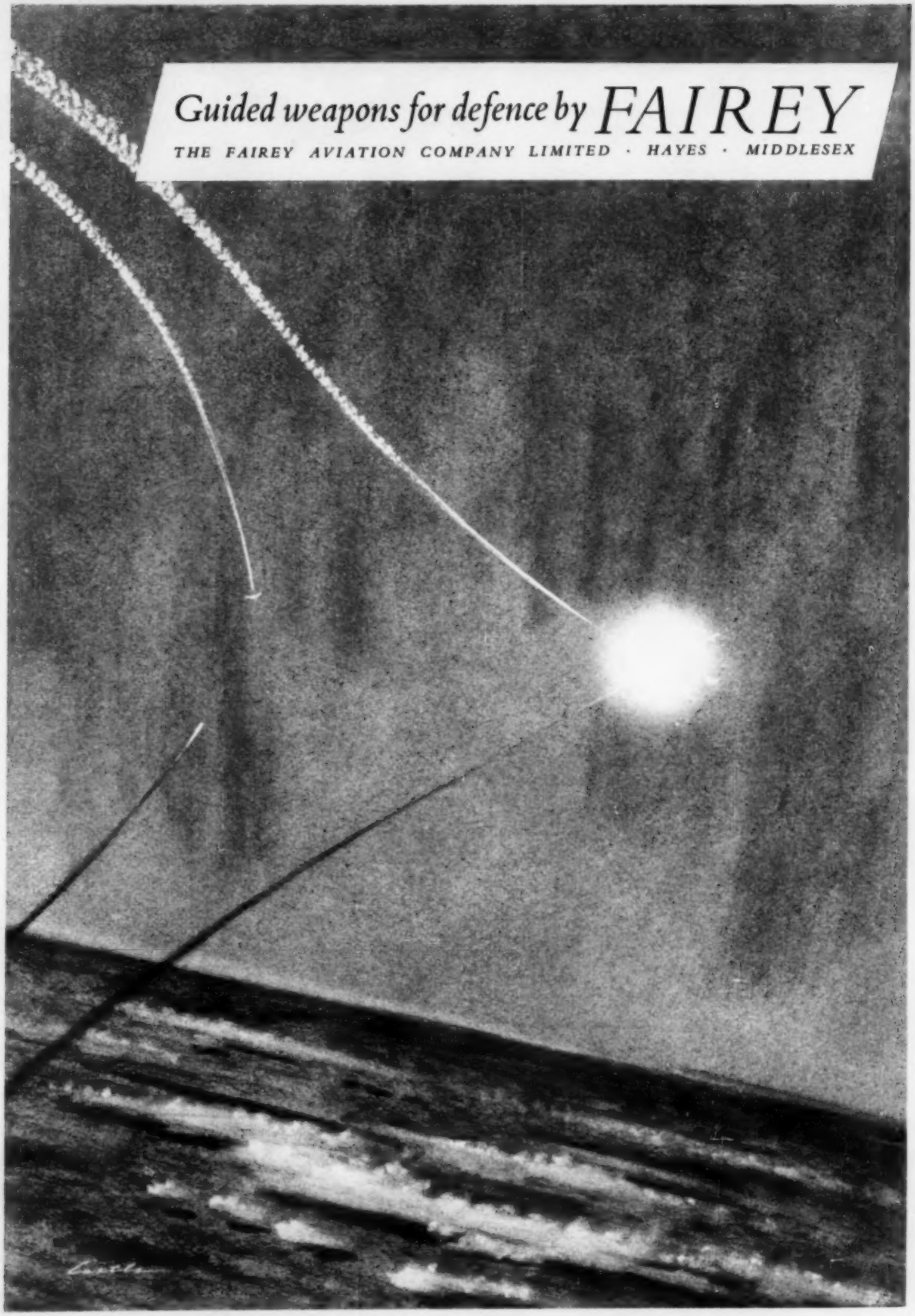
The minutes of a meeting summoned as a result of this letter included the paragraph: "Mr. Taylor said the first and second static tests revealed fatigue in three places which failed statically and that while the R.A.E. was satisfied that the static strength at these points would have been 100 per cent had they not been affected by fatigue, the R.A.E. was concerned with the fatigue. He was confident that, where remedial action had been taken to modify the structure, the fatigue strength would be satisfactory; but, having already experienced fatigue troubles, he wondered whether any other parts of the structure would be prone to fatigue failure. The fatigue strength of the wing under the firm's loading conditions was equivalent to an endurance of about 1/30 of the endurance under the R.A.E. conditions, and the R.A.E. considered this so low that it was advisable to consider the wing in detail."

These extracts, Mr. Harper said, illustrated that the wing only was being dealt with.

The first time the company's attention was drawn to the repeated-loading testing of pressure cabins was in October, 1952, when Mr. Harper, as a member of the Joint Airworthiness Committee, became familiar with the proposals for the testing of pressure cabins for military aircraft: 10,000 applications of 1.25 times working pressure were proposed.

The original tests carried out on the Comet nose-section (2,000 reversals at 9 lb/sq in) were not regarded as a fatigue test, but were intended to check for leaks and possible weakening of the whole structure. In 1953 the A.R.B. asked for 15,000 reversals at 1.25 times working pressure: it was thought that the pressure cabin, having an ultimate factor of 2.0, would be able to meet this requirement. Following the 2,000-reversal test (which indicated a life of 6,000 hr), a further 16,000 reversals were performed: this 18,000-hr total indicated a life of about 54,000 hr; the pre-loading effect was not ignored, but the safety margin was felt to be quite satisfactory for the foreseeable future. It was well ahead of the actual flying hours of any Comet, and continued testing would ensure that experiment kept ahead of the aircraft hours.

(*Late evidence: pages* 731-732)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AIRCRAFT INTELLIGENCE

I-PIAG, the Piaggio P.136 demonstrator, is shown converted to P.136-L standard, as described in the text (K & T, U.S.A.). This design is to be marketed in America as the Royal Gull.

U.S.A.

Douglas Skywarrior. It is reported from America that Douglas, like other manufacturers, has been having trouble with internally stowed weapons becoming "hung-up" in the bomb-bay owing to aerodynamic forces. On the A3D Skywarrior, a solution has been found by installing a spoiler, in the form of a miniature air-brake, which can be deflected immediately ahead of the front lip of the bomb compartment. A Douglas engineer has recently stated that the A3D all-up weight of 70,000 lb is roughly half the weight originally specified for an aircraft with equal capabilities. Later the U.S. Navy trimmed their requirements to 100,000 lb, and Douglas found that every pound of equipment saved made possible a reduction in airframe weight of nine pounds; some 550 lb were saved by eliminating ejection seats in favour of escape chutes. The present aircraft can, in theory, take-off vertically, under the power of two J57s and 12 JATO bottles.

K & T Royal Gull. Royal Aircraft, a subsidiary of the Kearney and Trecker Corporation, of Milwaukee, plans to import, assemble and market the latest version of the Italian Piaggio P.136 amphibian. As shown in the photograph, it has revised cowlings housing more powerful 270-h.p. Lycoming flat-six engines driving three-blade Hartzell propellers (earlier P.136s had Franklin engines, and 24 of these were built). The P.136-L can also be distinguished by its taller, square-tipped fin. Seating five, it cruises at 172 m.p.h. for up to 1,250 miles on 205 gallons. The Kearney and Trecker product will be marketed for $65,000 (£23,300) under the name Royal Gull.

North American F-100. In view of the difficulty which some British engineers and aerodynamicists are experiencing in trying to develop means for ejecting spent shell-cases and links from fighter aircraft, it is worth noting that the F-100A Super Sabre is fitted with simple ejection slots, one for each of its four 20 mm guns, through which spent cases or links are jettisoned. The use of simple slots is made possible owing to the fact that the F-100 has a nose intake and a very smooth, flat under-surface with a thick skin.

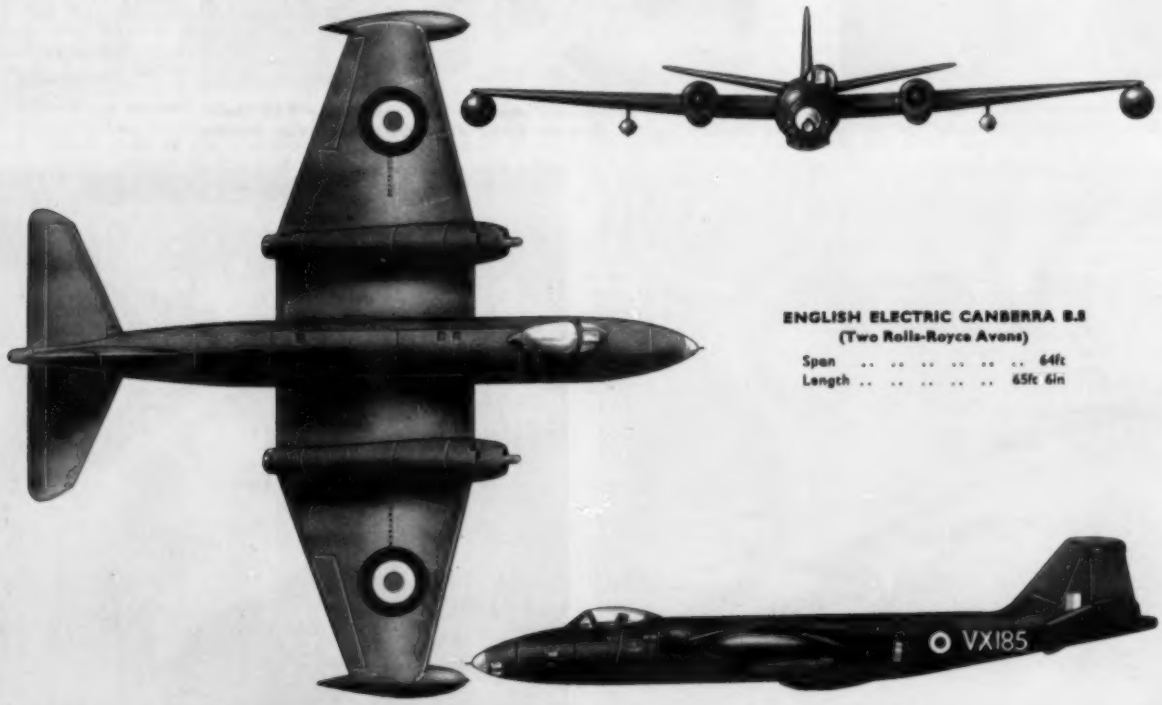
North American FJ-4 Fury. On October 28th, the first FJ-4 Fury made its first flight at the Columbus, Ohio, factory (picture, p. 736). The FJ-4 is the latest in a long line of carrier-based variants of the Sabre, and it is largely redesigned. Powered by a Wright J65-W-4 Sapphire of 7,800 lb thrust without afterburner, the new Fury has a completely new wing, with a greater chord, lower t/c ratio, and drooping leading edge. Large-chord flaps and drooping flaps-cum-ailerons (inboard) are fitted. The tail surfaces are also thinner than previously, and the fuselage is even deeper than that of previous Sapphire-powered Furies. The main undercarriage has a geometry almost identical with that of the F-100 Super Sabre. The FJ-4 is to be supersonic in level flight, and is armed with 20 mm cannon. It is in production.

France

S.N.E.C.M.A. V.T.O. In our issue of October 22nd last we published a photograph of a S.N.E.C.M.A. Atar turbojet mounted for test purposes in a vertical direction on a rig which simulates the behaviour of a v.t.o. aircraft. This work is being conducted under the guidance of Ing. von Zborowski. He is developing an aircraft with the power unit housed within an annular wing (the wing is in the form of a continuous aerofoil wrapped around the rear half of a central fuselage). S.N.E.C.M.A. do not go into details, but claim that their project—dubbed "Coleopter"—has "greater aerodynamic resistance, less weight and interesting aerodynamic symmetry."

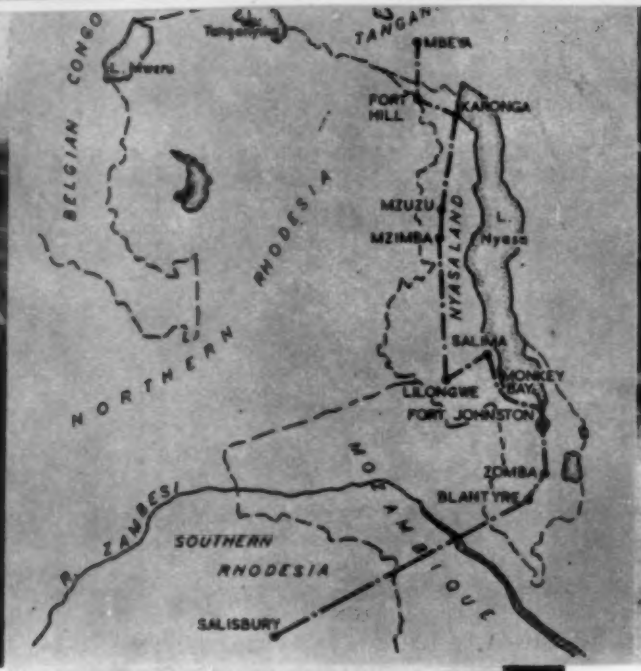
U.S.S.R.

Mig-15 According to the Italian journal *Alata*, the export price of a Mig-15 is about $155,000 (£56,000). The U.S.S.R. is reported to have been willing to sell Migs to "sympathetic" countries, including Finland and India.



ENGLISH ELECTRIC CANBERRA B.8
(Two Rolls-Royce Avons)

Span	64ft
Length	65ft 6in



The approach to Blantyre (above), indicating the Beaver's excellent forward visibility. The map (scale, about 160 miles to the inch) illustrates the journey on which these pictures were taken.

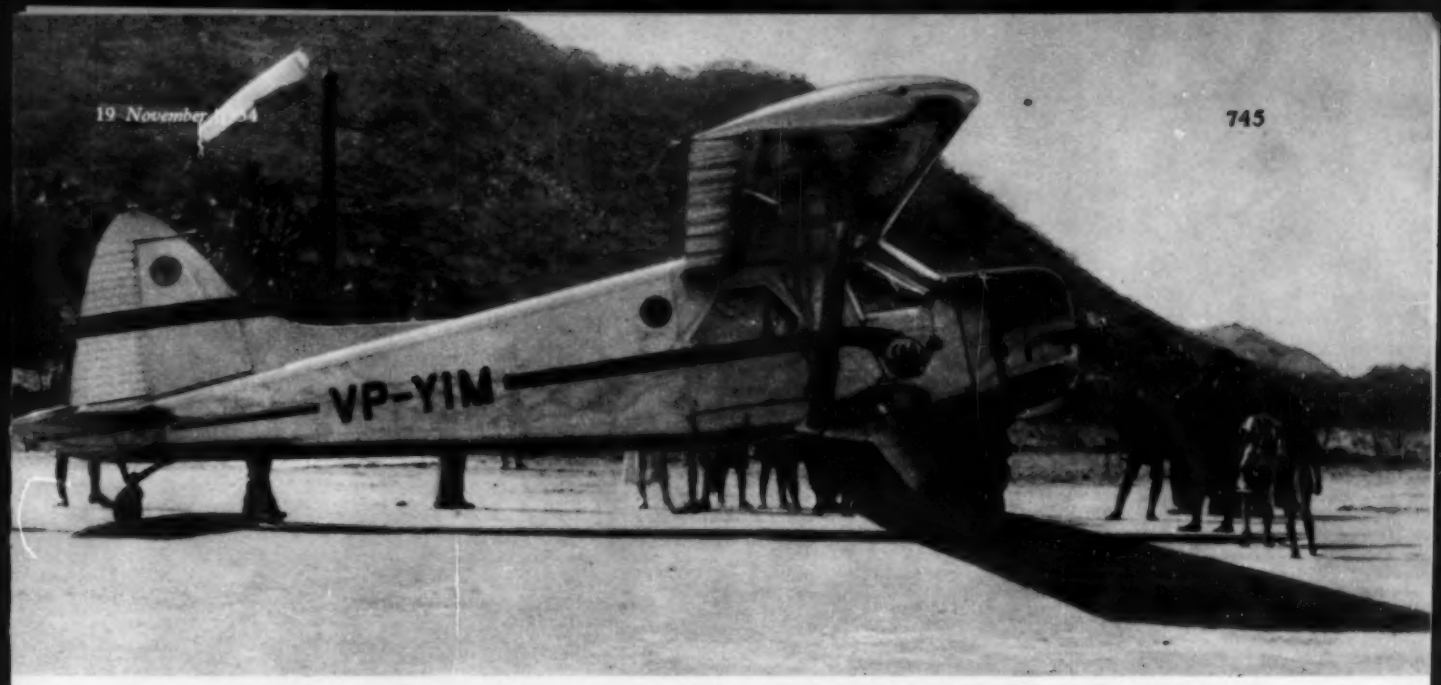
(Below) the Beaver's shadow races over Nyasaland.

(Above) C.A.A. Beaver at Monkey Bay, a colourful calling-point on the Nyasaland feeder service.

(Left) Typical Beaver country: an African village on the shore of Lake Nyasa.

"FLIGHT" photographs

All the types operated by Central African Airways—DC-3, Viking and Beaver—are shown in this control-tower view (below, left) of Belvedere Airport, Salisbury. On the right is the Zambesi, as seen from the Beaver at 10,000ft en route to Blantyre.



BEAVER SERVICE

Beating Round the Nyasaland Bush by C.A.A. Feederliner

By ROBERT J. BLACKBURN

THE speed of air travel coupled with the informality of a country bus service: this is the impression which I retain from two days' journeying around remotely populated parts of Africa by Central African Airways Beaver. My route, which is shown by the accompanying map, took in most of the 14 stations served by Beavers in Nyasaland. The airline has five of these aircraft, which operate two other networks covering 18 places, mostly in isolated areas, in Northern and Southern Rhodesia.

C.A.A.'s Beaver services, which began just over three years ago, are among the very few operated in the British Commonwealth with single-engined aircraft. Regulations normally require scheduled airlines to use aircraft with at least two engines, and the concession to the Beaver is a tribute to the reliability of this fine de Havilland Canada transport and its 450 h.p. Pratt and Whitney Wasp Junior. In cases such as this the combination of rudimentary airfields and sparse population means that air communications must be provided by a simple, sturdy aeroplane of this type or not at all.

The Beaver services are operated without hope of profit, but they are making an enormous contribution to everyday life in the remoter parts of the Federation. The existence of an air link, though perhaps only a weekly one, to a fairly large town or city means the end of isolation to some small communities on the Beaver routes, which may have as few as half-a-dozen European residents. It means also that mail will be delivered promptly and regularly, that supplies of fresh meat, milk and butter can be obtained weekly at reasonable cost, and that if the car breaks down the time taken to obtain a replacement part is reduced by several days.

The inevitable outcome of improving communications must be to speed up the development of any potentially prosperous area. The isolated few already in residence feel happier about staying; and prospective newcomers, learning that Salisbury, Lusaka or Livingstone are just a few hours away by air, are the more ready to move in.

In this way the existing feeder services are, no doubt, helping to create a demand for more frequent flights with larger aircraft. In 1952, I believe, C.A.A. attempted to withdraw the Beaver services on grounds of economy, but permission was refused in view of their social value. This suggestion would presumably not have been made had a separate subsidy been offered; but, like B.E.A. in the United Kingdom, the airline must attempt to offset losses incurred on social services with revenue from the longer-stage, higher-density routes.

I arrived in Salisbury on a Tuesday evening with three days or so to spare before setting off for Nairobi, and with the idea of seeing the Beaver in action as the main reason for my visit. To fly on the Nyasaland service seemed logical, as this not only offered some of the most attractive scenery in Africa but would also take me part-way to my destination. In order to pick up the Nyasaland service it would be necessary to fly 300 miles from Salisbury to Blantyre on the Viking departing at 9 o'clock the next morning. Incidentally, journeys such as this, which practically equals the distance between London and Cologne, are taken very casually indeed in Central Africa, where people who make regular use of scheduled airlines excite no more comment than the Englishman catching a train from, say, London to Birmingham or Bristol.

After checking-in at Belvedere Airport I was introduced to the pilot flying the Beaver service from Blantyre, Captain Mickey Delport, who courteously suggested that instead of boarding the Viking I should accompany him on the positioning flight.

As well as being an excellent pilot and a most likeable personality, Capt. Delport proved to be a man of many parts. Just before the outbreak of war, when he joined the South African Air Force to fly, he qualified as a lawyer, but preferring the cockpit to the court-room, has never practised as a civilian. He did, however, become judge-advocate of the S.A.A.F. and, for good measure, a Sabre pilot in Korea.

No less of a personality was Captain Theo Posselt, who took me on the next day from Lilongwe to Mbeya in another Beaver. After a lifetime's airline, charter and club flying in Central Africa, Captain Posselt settled down on a 16,000-acre cattle farm south of Salisbury. Now, he claims, the farm "runs itself," allowing him to return to flying for the simple but perfect reason that he likes it. And here I must say a word about the hard-working and immensely versatile people who, as full or part-time employees of C.A.A., act as station masters along the Beaver routes. Mrs. Fenner, for example, who combines the offices of airport commandant, station superintendent and traffic supervisor at Lilongwe (one of the busier stations) and still finds time to give dancing lessons—or her colleague, Mrs. Fenn, who works at the airport every morning, organizes the local amateur dramatics and acts as area correspondent for the Nyasaland newspaper.

As mentioned earlier, there is a genuine similarity between the work of the Beaver and the country bus respectively, but travelling conditions in the aircraft itself are more akin to those of the shooting brake or station wagon. One passenger sits on the right of the pilot and behind them is a bench-type seat for

Inhabitants of Monkey Bay take refuge from the sun under the wing of a transitory Beaver.

From Sabres to Beavers: Capt. Delport.

"FLIGHT" photographs

Another Beaver pilot, Capt. Posselt, with the Lilongwe airport staff: (left to right) Mrs. Jackson, Mrs. Fenn and Mrs. Fenner.

BEAVER SERVICE . . .

three more; this folds forward to admit a fifth passenger, who sits in solitary state at the back of the cabin with most of the remaining payload stowed on his left.

Single fares work out at around 8d a mile, which in many cases would be cheaper than the cost of using a car with only one occupant. And in every case the air journey would be far quicker and more comfortable. Where the single fare is more than £25 a passenger is allowed 66 lb of baggage; for shorter journeys the allowance is 44 lb.

Total payload of the Beaver is about 1,320 lb, or nearly a quarter of the all-up weight (5,100 lb). The freight load carried is nearly always determined by volumetric capacity available rather than weight limitation. Load calculations must be made with precision for an aircraft of this size, so all passengers and their baggage are weighed individually. The Beaver is cruised at about 130 m.p.h. which is an adequate speed for this sort of work. Average stages are so short that it would be wasteful to use faster aircraft, unless the additional speed could be obtained very cheaply.

Most of the stopping places on the Nyasaland route consisted of single grass or earth strips and a small hut. The length of strip was usually quite generous but more often than not its direction failed to coincide with that of the prevailing wind. Transit time at each calling point was 15 or, at the most, 20 minutes. A complete lack of formality was, I thought, one of the most pleasing features of the service.

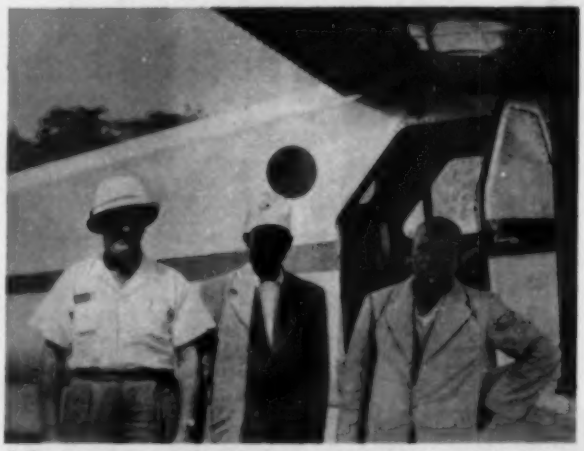
The sequence of events on a typical flight might be as follows:—

The pilot takes a final look at his load-sheet, puts out his cigarette (smoking is not allowed in the C.A.A. Beaver), turns to his passengers and says, "Let's go now, shall we?" Captain and passengers climb aboard, doors are closed and locked and, while an attentive African stands by with a fire extinguisher, the pilot presses the starter button. He makes sure that the passengers have their seat belts fastened, taxies out on to the strip, runs up the engine to check mag.-drop and pitch control, and takes off.

The Beaver really does "leap into the air," and by the time it reaches 50-100ft the pilot is already bringing power and r.p.m. levers back by inches. Even under the worst combination of weight, altitude and temperature conditions it never seems to require more than 200 yd for its take-off or landing. When the Beaver has settled down in cruising flight the captain hands round small packets containing sweets and cotton wool.

Refuelling at Karonga.

Even its best friend would not describe the Beaver's cabin as quiet, but nobody seems unsociable enough to make use of the cotton wool. Practically everywhere along the route we see smoke rising from bush and forest fires of varying size. These add considerably to the normal thermal turbulence experienced in this part of the world when the sun is high. By climbing to 10,000ft or so it is usually possible to find stable air, and this the Beaver will readily do. Such an altitude is not practicable on the shorter stages and the aircraft is thus liable to be tossed about quite severely at times. With its reassuringly rugged construction and high-wing layout, the Beaver rides the turbulence well. The sensation is in fact more akin to driving at fair speed along a bad road than to flight through turbulence when experienced in larger aircraft.



Fellow-passengers on the Beaver service: Mr. Brooker of the Africa Lakes Corporation with Chiefs Mlozi and Malomba, who flew from Lilongwe to see the co-operative rice plantation at Karonga.

Scenery on the Nyasaland route is always interesting and often superbly colourful—particularly when flying quite low over Lake Nyasa, whose blue waters contrast vividly with the yellow sand along the shore and the bright green fronds of the coconut palms beyond. Temperature in the cabin tends to be on the high side and one's increasing longing to bathe in the cool-looking waters of the lake is tempered only by the shock of recognizing the miniature but unmistakable shapes of crocodiles.

Heat and bumps notwithstanding, this is air travel at its most enjoyable. Many people will regret the day when, in the natural order of things, a larger, less personal aircraft comes along to take over the work so magnificently begun by the Beaver.

Roy Nockolds' design to illustrate "Endurance", upon which depends the effective striking power of fleets at sea, the forewarning of attack . . . the safety of aircrews and their aircraft. Endurance is a factor which aircraft designers have long sought to reconcile with high performance; the Double Mamba turboprop has been designed to meet this requirement.

THE DOUBLE MAMBA Basically two Mamba engines side by side driving independent co-axial four-bladed airscrews, the Double Mamba develops 2,950 e.s.h.p. Each unit is entirely separate; neither can be affected by loss of power or injury to the other. Specially designed for deck-landing aircraft,* the Double Mamba has the power potential, handling qualities and safety factors of a twin-engined aircraft, combined with the fuel economy and stowing facilities of a single installation.

* *The Fairey Gannet — super-priority for the Royal Navy — is powered by the Double Mamba.*

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ARMSTRONG SIDDELEY MOTORS LIMITED · COVENTRY

Members of the Hawker Siddeley Group

Safe ejection at

50ft.

500 knots.

LOW EJECTION AT CHALGROVE

To determine a minimum altitude at which a safe ejection is practicable, with their latest Fully Automatic Ejection Seat, the Martin-Baker Aircraft Company conducted air tests at Chalgrove Airfield, Oxfordshire, on 29th August, 1954.

During the tests an ejection was made from a Meteor aircraft flying at 512 m.p.h. at the remarkably low altitude of 50 feet. The ejection was completely successful, the main parachute being fully deployed before the dummy alighted without damage.

This astonishing feat was made possible by the employment of two stabilising drogues in tandem, designed to reduce, with acceptable deceleration, the speed of the seat after ejection and then to control the main deployment of the parachute thus eliminating the explosive opening characteristic. This seat was also fitted with the Martin-Baker Patent Barostatically Controlled Time Release Mechanism and Drogue Gun.

With this arrangement automatic separation from the seat after ejection occurs with insignificant loss of height, and safe escapes near the ground are made practicable. No other ejection seat is capable of this performance.

These design features are patented in the principal countries of the world.

Martin – Baker

AIRCRAFT COMPANY LIMITED - HIGHER DENHAM - NEAR UXBRIDGE - MIDDLESEX

CANBERRA TRAINERS

IN our issue of September 5th, 1952, we described the work of No. 231 Operational Conversion Unit, of No. 1 Group, Bomber Command. This unit was the first to be established for the purpose of training Canberra crews, this duty having previously been carried out by the operational squadrons themselves. When 231 O.C.U. was formed it was equipped solely with Canberra B.2s, and pupils were thus unable to receive dual training on the type; the procedure was for each pilot first to put in a number of hours on Meteor T.7s.

To meet the obvious need for a dual-control Canberra, the English Electric Company developed the T.4 variant, which is basically a B.2 fitted with side-by-side dual controls. Production Canberra T.4s are, of course, painted with the three-foot yellow training bands; apart from this, the only obvious feature peculiar to the type is the fact that it has a "solid" nose.

The accompanying photographs show T.4s of No. 231 O.C.U., where they have largely replaced the original B.2s. The conversion course has not been shortened; on the other hand, the T.4 has made it possible for every pilot to join a squadron with a full instrument rating. Formation flying is not in the syllabus at Bomber Command Conversion Units, and the quartet shown in the air-to-air pictures are being flown by instructors, led by the chief instructor, W/C. F. O. S. Dobell.

GETTING AWAY WITH IT

Martin-Baker Ejection Seats, Mks 2, 3 and 4

FOR many years people have been trusting themselves to parachutes, and comparatively few have come to any serious harm in the process. If the step is taken in reasonably favourable circumstances there is always a good chance of a not-too-damaging landing. But the risk involved and the percentages of failures have always been higher with military aircraft, because the conditions, for one reason or another, have seldom been ideal. With the advent of high-speed aircraft, the initial problem of clearing the machine has become almost insuperable without the assistance of the ejector seat, and all modern aircraft which can lay claim to any sort of high performance should be, and in most cases are, so equipped.

In the years since 1944 the Martin-Baker Aircraft Co., Ltd., have carried out the major part of the development and all the production work on a series of ejector seats which have been responsible for the saving of a number of lives. The first of their seats to go into production, the Mk 1, was described in *Flight* of August 19th, 1948. It was a non-automatic seat which, when fired, carried the pilot clear of his aircraft and released a small drogue designed both to decelerate and to stabilize the seat in mid-air. It was then up to the pilot to unfasten his seat harness, roll clear and pull the ripcord to deploy his parachute.

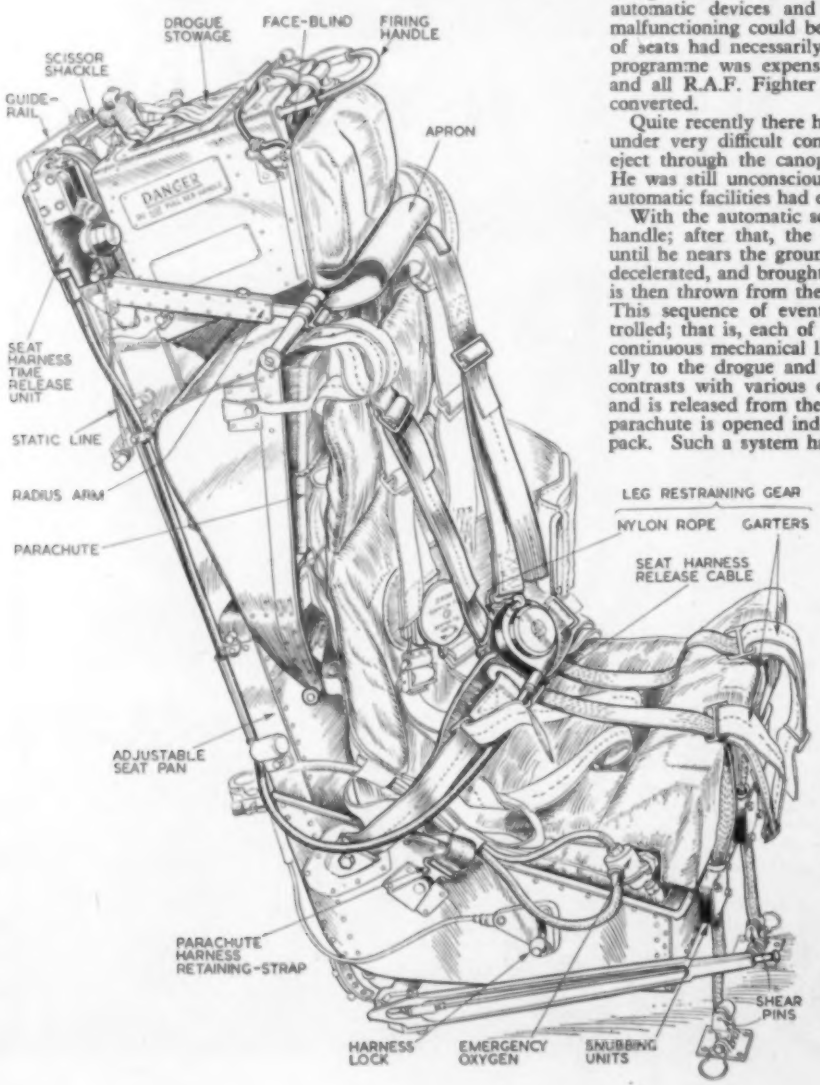
A blind protected his face from the airstream, and to use it he had to put his arms in the optimum position for ejection; thigh-guards restrained his legs from being splayed out by the airstream. This meant that if an aircraft got into serious trouble, the pilot knew that he could, in comparatively unfavourable circumstances, get clear and descend by parachute. But inevitably there were difficulties. In certain violent manœuvres following either on battle damage, mid-air collision, or structural failure, or simply because of lack of time, the pilot might be so violently thrown about as to be rendered unconscious immediately after ejection, and therefore incapable of performing the actions subsequently necessary to release himself from the seat and to open his parachute.

Martin-Baker therefore proceeded on their own initiative with the production of a conversion set by which Mk 1 seats could be adapted for fully automatic operation. A large number of firing tests was carried out to check the functioning of the automatic devices and film records were made so that any malfunctioning could be found and remedied. A large number of seats had necessarily to be written off in such tests, so the programme was expensive; but it was justified by the results, and all R.A.F. Fighter Command Mk 1 seats have now been converted.

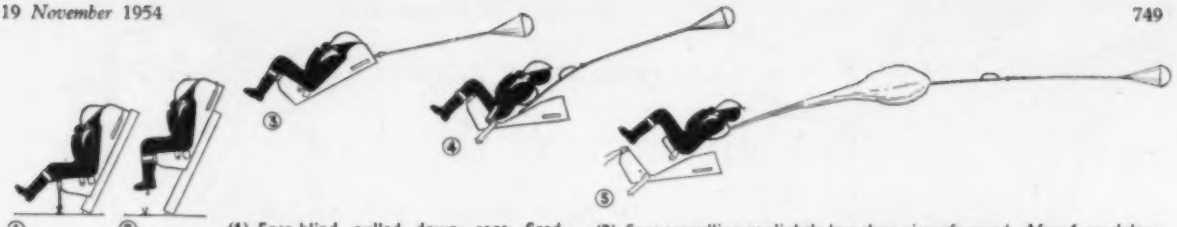
Quite recently there have been a number of successful escapes under very difficult conditions. In one case, the pilot had to eject through the canopy and was knocked unconscious by it. He was still unconscious when he reached the ground, but the automatic facilities had ensured a safe descent.

With the automatic seat it is necessary only to pull the firing handle; after that, the escaper's worries are over, at any rate until he nears the ground. The seat is automatically stabilized, decelerated, and brought to a safe altitude (10,000ft); the airman is then thrown from the seat and his parachute opened for him. This sequence of events in the Mk 2 seat is positively controlled; that is, each of the actions described is performed by a continuous mechanical link in the form of a cord attached initially to the drogue and finally to the parachute canopy. This contrasts with various other systems by which the pilot ejects and is released from the seat after a given time, after which the parachute is opened independently by a barostatic device in the pack. Such a system has been developed for the American Air Force, but it requires a considerably greater height margin than does the Mk 2 seat. At the same time, it has certain advantages concerned with the stabilization of the free-falling human body.

The Mk 2 seat, as the modified Mk 1 is now called, is fitted to almost every British military jet aircraft and has resulted in a considerably improved percentage of successful emergency ejections. The basic principle is that the pilot need do no more than jettison the hood and pull the firing handle. As the seat travels up the rails, two timing devices are triggered by tie-rod connections between seat and aircraft. One of these devices, on the left-hand side of the seat, fires the drogue gun one second after the main ejection charges. This forcibly extracts the drogue from its housing



The Mk 3 ejection seat, installed in the V-class bombers and other aircraft. It is automatic, and has leg restraint gear, quick-adjusting parachute harness and the long stroke gun.



(1) Face-blind pulled down—seat fired.

(2) Seat moving up rail tightens leg-restraining ropes, which then shear from floor.

(3) Seat travelling at slightly less than aircraft speed. After 1 sec delay, drogue gun fires, drogue streams and pulls seat to horizontal position. Deceleration begins. Legs securely lashed and hands holding blind.

(4) After 5 sec seat harness is unlocked and the scissor shackle opens, allowing drogue to pull directly on the lift lines, straighten the apron, and pitch the pilot forward. He is still held to the seat by the retaining straps, but the face-blind is released.

(5) Seat now travelling forward at 200 m.p.h. or less. Continued action of drogue and apron pulls out parachute and lifts pilot from seat. Drogue keeps canopy and lines stretched so that canopy opens relatively slowly, giving smooth deceleration. Normal parachute descent from this point. Face-blind can be removed. Apron and drogue remain attached to canopy.

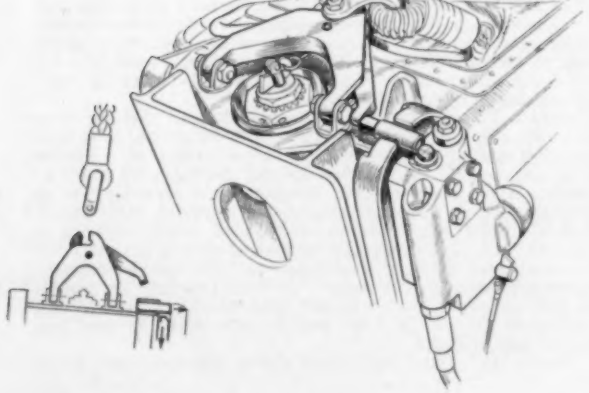
behind the pilot's head, to begin its stabilizing and decelerating task. At the same time the other timing mechanism, on the right-hand side of the seat, is released. A clock-like escapement controls the rotation of a spring-driven star-wheel, which gradually withdraws a piston projecting from the top of the timing box (see below). Should the ejection take place above 10,000ft, a barometric capsule is so distended as to insert a plunger between the teeth of the star-wheel, thus preventing its rotation. Above 10,000ft, therefore, the seat will fall free, with drogue extended and the pilot still firmly strapped in. Upon reaching 10,000ft, the capsule will have become sufficiently compressed to withdraw the pin from the star-wheel, allowing it to start turning. Rotation continues for the five seconds required to withdraw the plunger fully into the timing box, and two locks are simultaneously tripped. A sear, or latch, is withdrawn to release a spring-loaded plunger, which in turn pulls a cable connected to the seat-harness release, thus undoing the harness. Simultaneously, the shackle holding the drogue to the seat is released, so that the drogue pulls direct on the lift line. This releases the padded head-rest and also sharply straightens a canvas apron lying behind the parachute pack on the pilot's back, thus forcing his body clear of the seat. Lastly, it pulls the rip-cord and actually extracts the canopy from the pack. The forcible withdrawal of the canopy in this way ensures that both canopy and lift webs are fully extended before the canopy inflates. Opening shock is thereby considerably reduced.

To ensure that the seat falls away below the pilot and does not interfere with the parachute canopy, two retaining straps hold the parachute harness to the seat by spring clips which require a 100-lb tension to separate. Thus, after the seat harness is undone, the seat does not actually leave the pilot completely until jerked clear by the pull of drogue and canopy. The pilot is therefore held above the seat at all times.

If the ejection is made below 10,000ft the automatic sequence begins immediately, and the parachute is deployed five seconds after the seat is fired. This is fast enough to allow a reasonably safe ejection at 200ft above ground in level flight—a considerable and heartening improvement over the minimum safe height for the Mk 1 seat.

It is a requirement for automatic ejection seats that the occupant be provided with a means of over-riding the automatic facilities and of manually disengaging himself from the seat. In the Mk 2 and 3 seats this takes the form of two D-rings attached in the normal position on the parachute harness and so arranged that the second cannot be pulled before the first. To over-ride the automatic facilities the occupant pulls the top D-ring and disengages his parachute from the automatic rip-cord. He can then unfasten his harness manually, roll clear of the seat and pull the second D-ring, which is the normal parachute rip-cord.

Three-quarter rear view of the top of the Mk 3 seat. The operation of the scissor shackle and barometric timing device described in some detail in the text can be seen.



Features common to the Mk 1 and Mk 2 seats, are that the parachute is carried in a pan behind the pilot's back, while the seat pan contains the standard J-type dinghy pack with a comprehensive selection of survival equipment. The emergency oxygen supply, sufficient for ten minutes and automatically triggered when the seat leaves the aircraft, is contained in a padded roll along the forward edge of the seat, just beneath the pilot's knees. A thin layer of padding extends from the lower edge of the head-rest to the seat. The height of the seat pan can be adjusted by the pilot over 4in or 6in (according to the type of seat), so that the position of his head relative to the head-rest is correct for the operation of the firing handle. The handle must be pulled sharply over the face, so that the shaped blind encloses the head, because the firing cable runs along the centre of the blind and will fire the seat only in the last part of its travel. A horizontal pull will have no effect; the cable must be pulled down over the head to extend it sufficiently for firing. To allow the pilot to lean forward, a catch on the right-hand thigh-guard releases a ratchet and allows the parachute pan to swing forward on its lower mounting pivot. It is important that this pan should be fully back on ejection lest its upper edge injure the pilot's neck during firing.

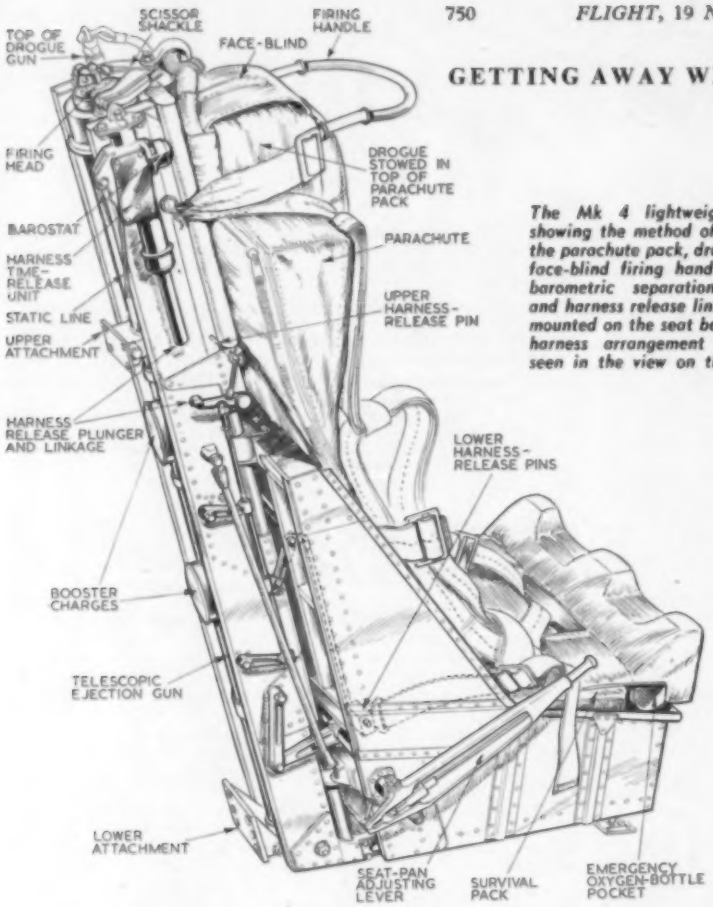
On entering the aircraft, the pilot must see that the safety pin is removed from the seat and placed in its stowage. He then sits down, fastens the four straps of his parachute harness, secures three quick-release dinghy attachments, fastens four seat-harness straps, plugs in his intercom and connects the main and emergency oxygen leads. With a spring-clip and chain, he finally secures his oxygen lead to a ring on his Mae West. This procedure can occupy a considerable time, and in fighter scrambles it is sometimes possible to perform only part of it.

In the event of ejection under high g loadings, considerable difficulty may be experienced in bringing the feet back into the stirrups, the position they should occupy for ejection. Furthermore, the parachute and dinghy pack remain in the aircraft at all times and frequently there is insufficient time to adjust the parachute harness for each successive occupant. A loose harness is undesirable in that it may injure the pilot when the canopy is deployed; and there is also the possibility that he may be thrown out of the harness altogether in mid-air.

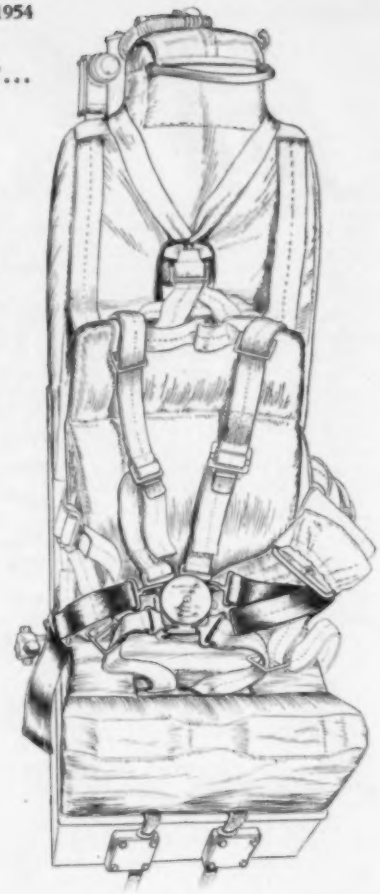
The Mk 3 "V" Bomber Seat.—Of two new seats shown on the Martin-Baker stand at Farnborough this year one was the Mk 3, which, it was stated, is to be fitted in the V-bombers. In this design the factors described in the preceding paragraph have been eliminated. The firing and automatic parachute release devices are the same as those of the Mk 2, except that a long-stroke gun with one primary and two boosting charges (as opposed to one primary and one booster in the Mk 2) provide the necessary ejection velocity to clear large vertical tail-surfaces. The stroke of the gun is 72in and the final ejection velocity 80 ft/sec; but the rise of g is rather lower than that of the shorter 43in-stroke gun, which has a 60 ft/sec velocity. It is considered that the long-stroke gun is necessary for bombers with tall vertical tail surfaces, and also for high-speed fighters.

The Mk 3 seat has adjustable arm-rests (in bomber applications) and, in view of the fact that ejection might take place at very high speeds, a Martin-Baker patent leg-restraint is fitted, since the load measurements on dummies' legs and thighs indicated the necessity for something more effective than the thigh-guard. In the leg restraint, nylon ropes run through two snubber

GETTING AWAY WITH IT...



The Mk 4 lightweight seat showing the method of stowing the parachute pack, drogue and face-blind firing handle. The barometric separation device and harness release linkage are mounted on the seat beam. The harness arrangement can be seen in the view on the right.



boxes on the front of the seat pan. One end of each nylon rope is attached by the pilot to a shoulder harness strap at the harness box after passing through rings on webbing garters sewn to the flying overalls. The other end is fitted with Duralumin spools. These spools fit into forked brackets on the floor of the aircraft and a light-alloy shear pin passes through the fork and the spool so that, when ejection takes place, the pilot's legs are drawn firmly in and the snubber boxes retain the ropes in that position. As the seat moves up the rails, the shear pins are broken; then, when the seat harness is subsequently unlocked, the ropes are freed, and the pilot's leg thus released from restraint. The leg restraints have been tested in live ejections—one from 30,000ft—and Mr. Lynch, Martin-Baker's test parachutist, reported favourably on the device.

The Mk 4 Lightweight Seat.—The other Martin-Baker seat shown at Farnborough was the Mk 4, which has been under development for some time and which, when fitted with the short-stroke 60 ft/sec gun, weighs 50 lb installed; with the 72in stroke, 80 ft/sec gun it scales just under 60 lb installed.

Parachute and seat harness are combined, so that six straps are fastened to a standard four-point parachute junction box and all six can be instantly adjusted by the pilot in the same way as a standard aircraft seat harness. When the seat leaves the aircraft, the seat harness is released at its mounting points on the seat and not at the junction box. To over-ride the automatic facilities, the pilot first pulls the top of the two D-rings normally fitted for this purpose. This releases the parachute from the automatic device. He then pulls a lever on the side of the seat, which unfastens the harness straps and, when clear of the seat, pulls the normal parachute D-ring.

The reduction in weight in the lightweight seat has been achieved by considerable ingenuity of design. The ejection gun, for instance, acts as a guide rail through runners fitted on each side of the barrel. Only a single lock is provided at the top to disengage the seat from the gun. The seat pan has 6in of height adjustment, controlled by a short lever which can be fitted on either side. There are only two attachment points between the gun and the aircraft structure, one at the base of the gun and the other adjustable at the top to pick up a convenient strong point in the aircraft. All the collar fittings on the outer tube of the telescopic gun are Redux-bonded to the tube, and tests have shown these joints to be completely satisfactory.

The Mk 4 seat is, like the Mk 3, provided with the leg-restraint gear in place of thigh-guards, but the nylon ropes can no longer be released from the junction box and are therefore attached to the roots of the lap straps. The system is otherwise identical with that of the Mk 3.

The parachute is stowed in a wedge-shaped pack behind the occupant's shoulders. The drogue gun and barostatic seat separation mechanisms are effectively the same as those of previous marks; but, since the seat harness disconnecting points are more in number and more widely separated, a mechanical linkage between them and the spring-loaded harness release plunger is provided. The method of releasing the drogue shackle to initiate seat separation is unchanged. The seat pan, containing survival pack and emergency oxygen supply, can still be adjusted for height relative to the parachute pack. The dinghy pack can be released and lowered on a 15ft lanyard during parachute descent and the dinghy can, if desired, be inflated by the pilot before he reaches the water.

It is understandable that the design of a radically new seat, such as the Mk 4 is, entails a multitude of modifications and detail re-design before the final product emerges. Numerous factors, many of them completely unpredictable, have to be taken into account in so specialized a business as ejection-seat development, and few of those engaged in the design work would be prepared to commit themselves as to the appearance of the final production Mk 4 seat. The most significant advance in the Mk 4 will be its compactness and light weight. These qualities are essential for most installations.

Aims and Problems.—It is undoubtedly true that the most convenient way of parting company with an aircraft is to have oneself forcibly thrown out at the mere pulling of a handle. It must also be realized that for the Service pilot a forced landing is no longer feasible except in ideal conditions; fields are too small for modern aircraft, glide approach speeds much too high, and the tail-down attitude of most machines at approach speeds is sufficiently marked to cause a most destructive nose-down pitch on a belly landing. For somewhat similar reasons, ditching is also "out." It must therefore be possible to bale out at all levels. At the opposite end of the scale the pulling of the handle must lead to safe escape at very high speeds and altitudes.

In the Mk 2 and 3 seats Martin-Baker have produced devices

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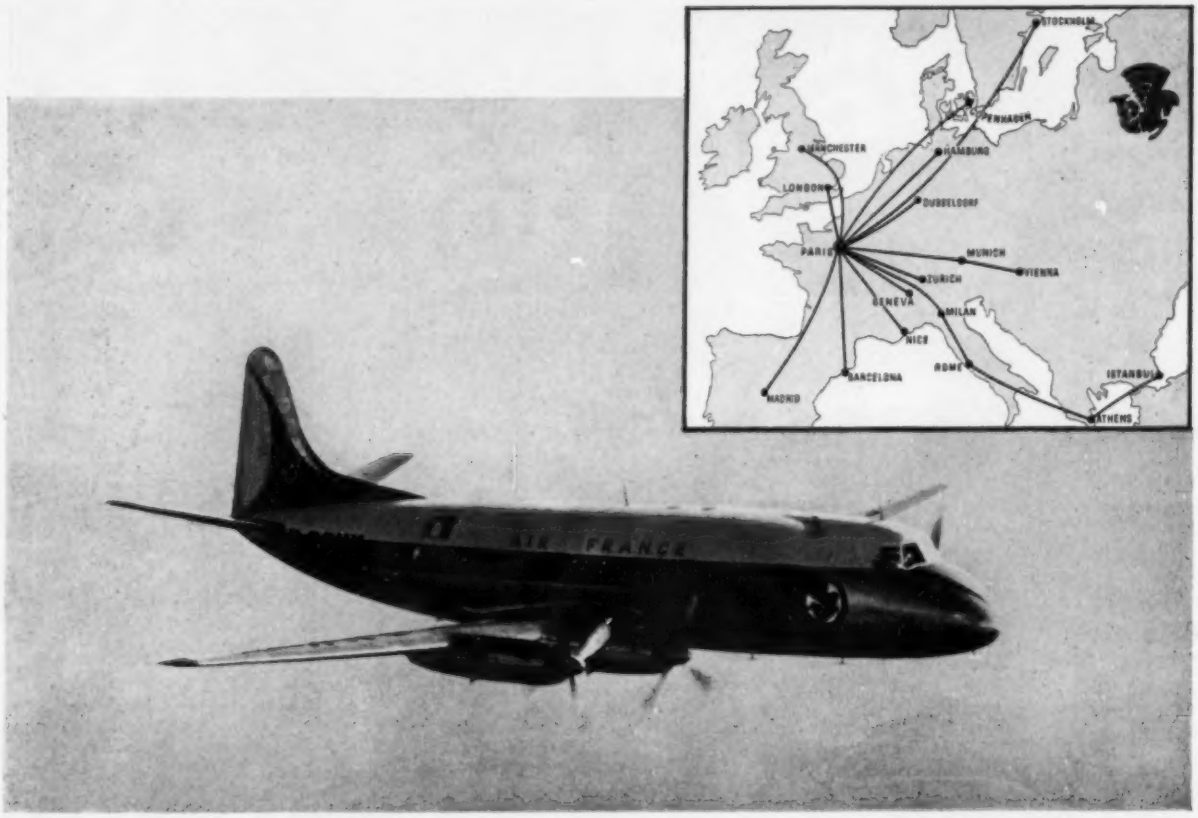

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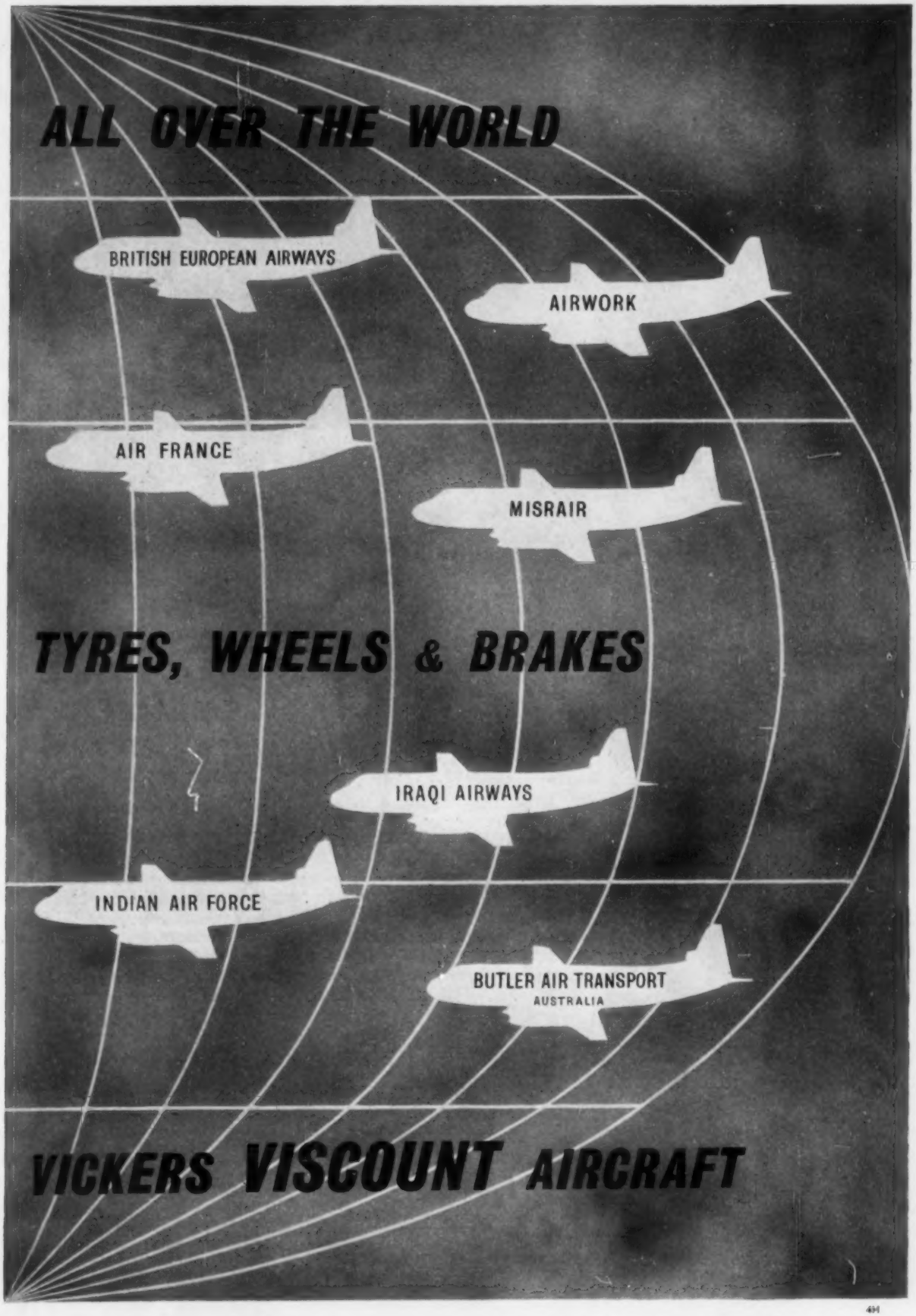
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Frame from the high-speed ciné-camera record of the 50ft, 500 kt dummy ejection, showing the two drogues, apron, parachute canopy and dummy as the parachute opens. The seat is attached to the dummy for test recovery purposes only.

GETTING AWAY WITH IT . . .

which will undoubtedly allow safe escape, as has on several occasions been demonstrated at reasonably high speeds and commendably low altitudes. But the matter is not being allowed to rest there. It is the declared object of the company to produce a seat which will function efficiently and completely automatically at any altitude down to, and possibly below, 50ft. Film records have in fact been made of one successful dummy ejection from the rear cockpit of a specially modified Meteor 7 stated to be travelling at 500 kt at 50ft. In this case, the automatic-separation mechanism was timed to open the parachute 2.5 sec after ejection. The seat left the aircraft in a stable vertical attitude and, after something under a second, a small primary drogue was released. This instantly jerked the seat into a horizontal attitude so that the large main deceleration drogue deployed immediately afterwards, exerted its very considerable g loading straight down the dummy's spine. After something over two seconds, the timing device released the shackle and the dummy was pulled from the seat and the parachute safely deployed. These actions were completed in 4.26 sec after firing, and the dummy subsequently descended to earth —now only some 20ft below—in a suitable (if, perhaps, somewhat dazed) condition for landing. It is intended that some such equipment shall be fitted to standard R.A.F. seats in the future—though, of course, such a high-speed escape at such a low altitude is very much a last resort.

Standard seats can, however, be converted for this type of escape simply by adding the large drogue to the small one and by altering the setting of the timing mechanism from 5 to 2.5 sec. It is claimed that ejection could then be made at 50ft at any speed. Martin-Baker also claim they can arrange for an override which would cause the parachute to open instantaneously after ejection, so that the pilot could get out even on the runway provided he had a speed not less than about 120 m.p.h.

The initial impact on the human body of a 500 kt airstream is so violent that it may well cause serious damage, and the problem of opening a parachute at high speeds must be considered with the utmost care. An ejection at low speed at 50ft presents yet another problem, since the falling time is decreased when the high forward motion on ejection is not present.

Finally, in all installations hitherto revealed, it has been necessary for the pilot to jettison his canopy manually before pulling the firing handle. If this malfunctions, or when there is no time to perform the operation, the only alternative is to eject through the hood. This has been successfully done on several occasions, but is obviously not a desirable feat. Martin-Baker have designed and fitted to several recent aircraft, explosive hood-jettison gear linked with the seat firing mechanism. Thus, when the pilot pulls the ejection handle, a charge is fired in a time-controlled breach mechanism. The gas pressure activates two jacks, one on each side of the cockpit which, in the first part of their movement, unlock the hood and then shoot it clear. At the same time, a clock is started and the sear is withdrawn from the seat, to fire it about one second later. The delay is designed to give a separation between the flight paths of the hood and the seat.

Whatever the inherent snags of various types of ejection may be, it is true to say that the introduction into R.A.F. service of the Mk 2 automatic seat has very markedly increased the chances of successful escape in emergency, and the confidence it gives is considerable. But the overall problem of completely safe and certain emergency escape, especially at extreme altitude, is not yet completely solved. The capsule-type jettisonable cockpit at one time appeared to provide the ideal solution, but it was found that the weight of any capsule would be too high to allow deceleration and safe descent after low-level ejection; and the wearing of an automatically triggered partial-pressure suit would eliminate the need for a capsule in maintaining pressurization at very high levels. The solution will probably lie in the addition of some form of shielding on the seat itself to protect the pilot from very-high-speed airstreams—although such protection will probably only be required in a comparatively small percentage of the escapes which will be made from high-speed aircraft.

C. M. L.

A.T.C.O. GUILD GATHERING

THE degree of responsibility at present held by air-traffic controllers at both civil and military aerodromes has been reflected in the recent formation of the Guild of Air Traffic Control Officers. At a cocktail party in London on November 4th, the Master of the Guild, Mr. C. A. Robinson, A.F.R.Ae.S., spoke of its functions: one of the Guild's objects is "to promote honourable practice and maintain in the profession a high standard of efficiency and integrity dedicated to the safety of those who seek their livelihood or pleasure in the air."

Membership of the Guild is open to air-traffic control officers, at both Service and civil aerodromes, who are British subjects and have the necessary qualifications. Experience in the profession and the possession of the appropriate licences or their equivalent are essential, but those with limited qualifications may be considered for associate membership. At present, the Guild shares the Pathfinder Club's H.Q. at 118 Mount Street, W.1 (Mayfair 5982). The Clerk of the Guild is Mr. W. C. Woodruff.

CANADIAN FORESTRY AIR SERVICE

A SPECIAL air service is maintained by the Department of Lands and Forests in Ontario to guard against forest fires. The risk of outbreaks is considered to have grown in proportion to the increase in population, especially since the development of mineral resources began. The service was first established in 1924 under Roy Maxwell, and its pilots have since flown some 238,000 hours. Headquarters are at present at Sault Sainte Marie, and, of a total of 42 aircraft, 31 are assigned to forestry districts, four (three Otters and a Dove) are held for special requirements, and the remainder are kept in reserve at Soo. Most of the aircraft are Beavers, but a number of Otters are also used.

The majority of the pilots are recruited from Canada's "bush pilots," since they must already have experience of operation with float and ski landing gear. Few of the many ex-R.C.A.F. applicants have this variety of experience. Flying procedures are standardized in much the same way as on the airlines, and pilots receive periodic handling checks.

CORRESPONDENCE

The Editor of "Flight" does not hold himself responsible for the views expressed by correspondents in these columns; the names and addresses of the writers, not necessarily for publication, must in all cases accompany letters.

Auxiliary Power in Aircraft

AS a temporary visitor to your country from the U.S.A., it happens that I have just seen your article of August 13th under this heading, and almost at the same time heard the following.

A four-engined aircraft with a gas turbine auxiliary power unit was recently flying about two hours out over European waters. Conditions were 10,000ft, icing and night. All generators of the main engines went "out," thus leaving the aircraft with about three to five minutes' battery supply for even such vital purposes as airscrew de-icing.

The A.P.U. was brought into action, and the aircraft successfully returned, all subsequent electrical demands, instruments, propellers, lighting, radio, etc., being supplied by the A.P.U.

In this case it may reasonably be said that some 250 lb of A.P.U. saved, or at least contributed generally to the saving of, the aircraft and its occupants.

Washington 6, D.C. BILL HENRY.

Gnats for NATO?

AS the U.S. Secretary of the Navy has pointed out, the Soviets have an aeroplane which is able to deliver atomic weapons with supersonic speed, so the problem of European air defence becomes still more complicated.

Today there exists no European fighter able to attack these new Russian aeroplanes, and the American F-100 will certainly not be in service with the American Air Force in Europe for at least two years. So it is very important for Europe to get a fighter into service that can fill the gap.

Fortunately, England has a fighter which could take over this rôle. I am thinking of the Folland Gnat, which will be supersonic on the level. The Gnat, cheap and simple to build and maintain, could be in service very soon if the R.A.F. or NATO were to place a substantial super-priority order in the near future. By virtue of the cheapness of the aircraft, even the poorer nations could afford to build sufficient numbers in adequate time.

The armament of the Gnat, two Aden guns, should be sufficient to shoot down all except the heaviest aircraft. But a Gnat armed with rockets, like the F-94C Starfire, would be an even more powerful opponent. The rockets could be stowed in an underslung housing like that of the Canberra B.8, or in auxiliary fuel tanks, which will certainly be fitted sooner or later to improve range.

It is also important that a supersonic night and all-weather fighter comes into existence. The Soviets would certainly not attack only in good weather conditions. For the first time an aircraft resembling the Javelin, and able to achieve supersonic speed on the level, could be a possible solution. Perhaps more powerful engines would help, or some aerodynamic refinements. But it would be best to develop a not-too-heavy night fighter with extraordinarily low stalling speed.

Aircraft that are able to take off from undeveloped airfields are urgently needed, because well-equipped airfields would in war-time soon be damaged to such a degree that only aircraft requiring short runways could use them.

Schondorf-Ammersee, Germany. HANS H. SCHICHT.

Standardization

YOUR Editorial "Making Work" (*Flight*, November 5th) is interesting, timely, and of great importance to the security of the country. It asks "Why does every fighter have a different wheel and tyre size?" There is no logical reason at all.

There is in existence a M.o.S. Standard Design Memorandum on aircraft tyres. This gives the correct size for various ranges of pressures, the intention being that, at the beginning of the life of a particular aircraft, the tyre selected should give the desired deflection at the lower end of its recommended pressure range. Then, as the a.u.w. increased as the aircraft was developed, so the inflation pressure would be increased towards the upper limit of the range.

It would appear that departures from the recommendation of the S.D.M. have been permitted, with the result that many aircraft have commenced their service life with a tyre pressure at, or in excess of, the recommended maximum. Thus, any increase in weight can only be accommodated by a further increase in the tyre pressures already above the desirable maximum, or by fitting new wheels, tyres and brakes. This is expensive because of the high cost of the complicated moulds and pattern equipment required and often has the added disadvantage of introducing an odd size which is not listed in the S.D.M. and details of which are known only to the manufacturer of the prototype equipment, competitive tendering thus becoming a mere formality and the ready supply of world wide spares jeopardized.

One of our latest prototypes is, in fact, fitted with tyres inflated to over 60 lb sq in, whereas the maximum pressure, as stipulated in the S.D.M., is only 35 lb/sq in!

Three different mainwheel tyre sizes have already been fitted to one well known aircraft now in R.A.F. service. One would have been sufficient if the correct size had been selected at the outset.

It is estimated that 65 per cent of our latest types of aircraft are fitted with tyres not listed in the S.D.M. In fact, this particular Memorandum has been so effectively ignored that it is about to be cancelled. Far from more standardization on tyres and wheels, we are now well on the way back to the free-for-all existing before the war.

The position is serious. If hostilities were to break out tomorrow most of our front line warplanes would be dependent upon the supplies of *one* factory. Yes, more standardization is required—particularly on tyres.

London, S.E.19. MAURICE F. ALLWARD.

IN BRIEF

A reader enquires as to the value of a considerable number of very early copies, both bound and unbound, of *Flight* and *The Aero*. Details are: *Aero*, July 5th-December 28th, 1910, bound; March 22nd-June 28th, 1910, and January 4th-March 22nd, 1911, consecutive issues, unbound. *Flight*, January-December 1911 (in two volumes), bound; 1912 and 1913, consecutive issues, unbound. Various odd copies of *Flight* between 1910 and 1918 are also available. Letters marked "W.J.", c/o the Editor, will be forwarded.

FORTHCOMING EVENTS

Nov. 20. British Interplanetary Society (North-West branch): "Extra-Terrestrial Observatories," by C. A. Cross, M.A.
Nov. 20. British Interplanetary Society (provisional Yorkshire branch): "Space Vehicles," by D. A. Parish.
No. 23. Helicopter Association: Films, in association with the R.Ae.C.
Nov. 24. British Institution of Radio Engineers: "Direct Coupled Cathode Ray Oscilloscopes for Industry and Research," by M. J. Goddard, A.R.C.S., M.Sc., D.I.C.
Nov. 24. R.Ae.C.: Dinner for presentation of De La Vaulx Medals and Paul Tissandier Diplomas.
Nov. 24. R.A.F. College, Cranwell: Rugby v .R.A.F.
Nov. 25. R.Ae.S. Section Lecture: "Development and Investigation of Fatigue Cracks," by Dr. N. Thompson, B.Sc.
Nov. 25-26. Institute of Metals: Discussions on papers dealing with titanium and other subjects.
Nov. 26. Lighter-than-Air Reunion, Londonderry House.
Nov. 26. Surrey Flying Club: Dance.
Nov. 27. R.A.F. College, Cranwell: Rugby v. R.N.C., Greenwich.
Nov. 27. British Interplanetary Society (provisional Scottish branch): "The Rocket as a Scientific Instrument," by H. W. Ovenden, M.A., B.Sc.
Nov. 27. British Interplanetary Society (provisional Western branch): "Possible Methods of Propulsion in Space," by L. R. Shepherd, Ph.D., B.Sc.
Nov. 30. Guild of Air Pilots and Air Navigators: 25th Anniversary Celebrations.
Dec. 1. R.A.F. College, Cranwell: Soccer v. Nottingham University.
Dec. 2. R.Ae.S. Graduates' and Students' Section: "Development of Water-based Aircraft Design," by R. F. R. Storey, B.Sc.
Dec. 3. R.A.F. College, Cranwell: Boxing v. R.M.A., Sandhurst.
Dec. 4. R.A.F. College, Cranwell: Rugby v. R.M.A., Sandhurst.
Dec. 4. British Interplanetary Society: Annual general meeting.
Dec. 8. R.A.F. College, Cranwell: Hockey v. Nottingham University.
Dec. 9. R.Ae.S. Section Lecture: "Problems of Structural Design," by D. James, B.Sc., A.F.R.Ae.S.
Dec. 10. International Federation of Air Line Pilots' Association: Technical meeting on airborne radar.
Dec. 10. Helicopter Association: "Possibility of the Flight Simulator as a Training Aid to Helicopter Pilots"—informal discussion, to be opened by Norman Hill.

R.Ae.S. Branch Fixtures (to Dec. 10): Nov. 22, *Henlow*, "The Aeroplane and its Engine," by A.Cdre. F. R. Banks. Nov. 22, *Belfast*, "Plastics in Aircraft," by H. Baker. Nov. 23, *Boscombe Down*, "Bird Flight," by Capt. J. L. Pritchard. Nov. 24, *Bristol*, "User Problems in Industry," by B. S. Shenstone.
Dec. 1, *Luton*, "Rubber."
Dec. 7, *Bristol*, "Living Machines," by W. Grey Walter. Dec. 9, *I.O.W.*, annual general meeting and film show. Dec. 10, *Bristol*, Christmas Ball (jointly with Inst. C.E., Inst. Mech.E. and Inst. S.E.).

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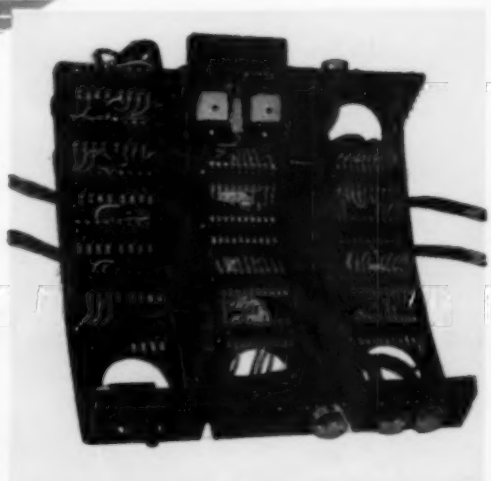

Electrical Supply Panel—Hawker "Hunter". A typical example of preformed wiring employing Plessey components. (Photographed by courtesy: Hawker Aircraft Ltd.)

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CIVIL AVIATION

On Monday last S.A.S. inaugurated the world's first regular trans-atlantic services to follow an Arctic route—twice-weekly DC-6B flights between Copenhagen and Los Angeles. Refuelling halts are made at Sondre Stromfjord, Greenland (known also as Bluie West 8 and illustrated above), and Winnipeg.

THE VISCOUNT AND THE C.A.A.

FINAL agreement between the Air Registration Board and the Civil Aeronautics Administration on the U.S. certification of the Viscount was announced on November 10th. By this agreement, the two airworthiness authorities have settled the outstanding points which stood in the way of American validation of the Viscount's British C. of A.

Vickers-Armstrongs, makers of the Viscount, say it enables "the basic requirements of all parties to be satisfied without any significant operational or economic penalty to the Viscount as offered for certification." The agreement provides: (1) That all Viscount performance should be based on the C.A.A. standard humidity as currently used in evaluating the performance of American aircraft. Previously the British data supplied to the C.A.A. had been based on tropical performance measurements at high humidity. (2) On those routes which are subject to a "two-engine failed" requirement, the *en route* rate of climb with two engines failed should be 0.005 VSO^2, which is to be applied with full temperature accountability. The requirement for a rate of climb on a "standard day" remains at 0.01 VSO^2.

The significance of the agreement is lucidly explained in a note from the manufacturers. The main point which emerges is that, contrary to certain disconcerting but vaguely worded reports from British correspondents in America, the Viscount's commercial performance in service with Capital Airlines will not be measurably penalized by C.A.A. requirements. The note reads as follows:—

"The term 'VSO' is used to denote the stalling speed of an aircraft with wheels down, flaps in the landing position, and power off. This stalling speed is the basis of various arbitrary rate of climb requirements in the U.S.A. airworthiness code.

"The 0.005 VSO^2 quoted in the agreement works out, in the case of the Viscount, at a rate of climb of 54 ft/min, based on a stalling speed (i.e., VSO) of 104 m.p.h. at current maximum take-off weight:—e.g., $0.005 \times (104)^2 = 54.08$ ft/min.

"The United States rule which this agreement supplements is only applicable to those routes on which the aircraft is, at any time, more than 90 minutes' normal flying time away from a suitable airfield. It requires that, in the event of two engines failing on such a route, a minimum rate of climb shall be available at the appropriate weight and altitude. A comparable rule embodying temperature accountability is in force in the United Kingdom. In airline practice the captain of an airliner about to take-off on a flight over such a route can consult a chart in his flight manual. By applying the temperature prevailing he can then read off the maximum permissible weight for take-off on that day.

"There are, of course, other standard factors which can affect maximum take-off weight, such as runway length, height of neighbouring obstacles, etc.

"The 'standard day' mentioned in the agreement is one on which the temperature is 15 deg C (59 deg F). In effect, the agreement provides that, on such a standard day, the Viscount's rate of climb with two engines failed will not fall below 0.01 VSO^2 (108 ft/min) and, on a hot day, it will not fall below 54 ft/min.

"The reference in the agreement to humidity covers the fact that the British data provided dealt with the Viscount's performance at both high temperature and at high humidity. The data on humidity has now been re-evaluated on the standard U.S.A. basis, i.e., on drier air.

"The result of the agreement is that the en-route climb requirements which are to be applied will not result in any reduction in the Viscount's maximum take-off weight on the routes operated by Capital Airlines at any shade temperature below those of the order of 110 deg F. Such conditions are very rare indeed at any airfield on the Capital network.

"The agreement between the A.R.B. and C.A.A. does not involve the issue of a U.S.A. Certificate of Airworthiness to the Viscount at this stage. Such a C. of A. cannot, by standard practice, be issued until an aircraft complying with the agreement is actually in the United States. No Viscount will be delivered there until next spring and consequently no C. of A. can be issued until then. The agreement, however, prepares the way for the issue of the Certificate at the appropriate time."

SHANNON INQUIRY

THE official Eire Government inquiry into the K.L.M. Super Constellation accident in the Shannon Estuary on September 5th will begin on November 29th in Dublin. It will be conducted by Mr. Justice Teevan with the assistance of four assessors.

Persons in a position to give evidence which might assist the investigation, or those wishing to appear or to be represented, are asked to write to the Registrar of the Court of Inquiry, Department of Industry and Commerce, Kildare Street, Dublin, to whom enquiries about the investigation should also be sent.

CORPORATIONS' AMERICAN APPOINTMENTS

A NUMBER of B.O.A.C. and B.E.A. appointments in the U.S.A. have recently been announced. Mr. Harry Good, in charge of the Eastern Sales Division in the U.S.A. for B.O.A.C. since 1947, has been appointed assistant sales manager, U.S.A., responsible to Mr. Paul Bewshea (sales manager, U.S.A.). Mr. George Boughton, manager, North America for British European Airways since 1952, has left B.E.A. to become sales development manager, U.S.A., for B.O.A.C. Mr. George Wharton, previously assistant to Mr. Peter Masefield, B.E.A.'s Chief Executive, succeeds Mr. Boughton in North America. Mr. C. Louis Davies has been appointed sales representative in the San Francisco office of B.O.A.C., succeeding Mr. David Haviland.

Named "Sir Ector," and shown in its new B.E.A. livery, this S-55 is the first of two ordered for a shuttle service between the South Bank site and London Airport.

CIVIL AVIATION . . .

Trans-Canada Air Lines' first Viscount 724 is seen during final checking before delivery across the Atlantic later this month. These aircraft are characterized by numerous detail differences, and they introduce the Rolls-Royce Dart 506, which provides better cruising power and economy.

WEST AFRICAN HERONS

AN order for three de Havilland Heron 2s, to be delivered early next year, has been placed by West African Airways Corporation. They will be used on W.A.A.C.'s extensive network of local services in Nigeria, the Gold Coast and along the West African Coast from Dakar to the Cameroons.

MORE DC-6As FOR AMERICAN AIRLINES

THE tenth anniversary of scheduled all-freight services by American Airlines coincided with the company's announcement of an order for seven Douglas DC-6A Liftmasters at a total cost of £3,400,000.

The three DC-6As already in service with American Airlines are distinguished by their lack of cabin windows, reducing weight and cost of construction. They are operated on nightly coast-to-coast services, carrying up to 28,500 lb each. The additional DC-6As will begin to enter service in the spring of 1956.

THE KALLANG INQUIRY

AN error of judgment by the captain caused the accident to B.O.A.C. Constellation G-ALAM on March 13th this year at Kallang Airport, Singapore. This finding is contained in the report* of the Public Inquiry into the accident, which was conducted by Mr. Justice Knight in the Supreme Court, Singapore, between May 31st and August 16th.

The aircraft, which was making a scheduled flight from Sydney to London, landed just short of the threshold of runway 06 at Kallang, apparently placing an excessive strain on the undercarriage and disrupting an integral fuel tank. The starboard undercarriage collapsed when the aircraft first touched the runway after an 80-yd bounce; the starboard wing broke off at the root and the aircraft was already on fire when it came to rest on its back. All 31 passengers died, together with one of the two stewards. Eight of the crew escaped but one, the stewardess, died of her injuries.

The Captain (Capt. T. W. Hoyle), first officer, radio officer and the two engineers left the cockpit by way of a 14in × 10in clear-vision panel. The navigator and a steward escaped through a gash in the fuselage forward of the door between the crew compartment and the passenger cabin, which was jammed, and the stewardess was brought out through a hole made in the wall of the crew compartment with an axe.

"It seems fairly certain," the report says, that none of the passengers was killed in the crash and that many were still alive and conscious at least six to eight minutes after the aircraft had come to rest. Apparently no attempt was made to use the three emergency exits from within, but this might have been due to the inverted position of the aircraft and also to their proximity to the fuel tanks. The main cabin door was jammed.

Attempts to bring out passengers through holes cut in the fuselage were almost completely unsuccessful; only two people were extricated alive and both died before reaching hospital. The Court found no evidence of any "sustained or concentrated effort . . . to break into the main cabin during that critical period" adding that "the heaven-sent opportunity of gaining access through the rear pressure-bulkhead was not pressed home until much later, and it must not be forgotten that the opening of this bulkhead presented no difficulty once it was tackled with some such tool as an axe or crowbar, quantities of which were available in either the crash rescue jeep or the foam tender a mere 30ft from the bulkhead."

Much of this lengthy (46 pages) report is devoted to the inadequacy of the airport fire unit at Kallang, whose members, it says, lacked leadership, technical training and efficient equipment. The report says that blame for the inadequacy of the fire service "must rest on the shoulders of Mr. Savage," Director-General of Civil Aviation, Singapore, from 1949 until November 1953. It is stated that Mr. Savage gave no acceptable explanation for the deterioration of the fire service during his term of office and that "from the whole trend of his evidence it is quite clear that he showed little interest in the fire service and considered it to be of no effective value as a means of dealing with a fire involving a heavy pressurized aircraft."

Following publication of the report, the Governor of Singapore, Sir John Nicoll, issued a statement expressing his disagreement with two criticisms levelled against Mr. Savage which, in the opinion of the Governor, were a reflection on Mr. Savage's integrity. The Governor's statement accepted the report's criticisms of the deficiencies of the airport fire service and outlined the steps taken to improve it after the accident.

Regarding criticisms of the behaviour of the crew immediately after the accident, the report says that "it would not be fair to censure them for their conduct, though it cannot be commended." Members of the crew, it states, were suffering from shock and had to contend with darkness and noxious fumes.

Regarding the cause of the accident and the death of the passengers and crew members, Mr. Justice Knight concludes his report as follows: "In view of the distinct possibility that Capt. Hoyle's error of judgment was influenced by the fact that he was tired, I do not think that the accident was caused or contributed to by his wrongful default. Similarly, no wrongful act or default was responsible for the fact that no passenger was rescued from the aircraft. The Department of Civil Aviation did not believe in the possibility of a fire service being able to help passengers in the event of a fire involving a heavy aircraft. From the evidence I have heard in this Court, I believe that view to be wrong."

The report includes nine general recommendations and six specific recommendations in respect of Kallang Airport. One of the former outlines the need for study into the effects of crew fatigue. Having earlier noted that Capt. Hoyle had been on duty for 21¼ hr at the time of the accident, it observes that it is by no means certain how much his tiredness affected his judgment in the last stages of the approach. Other important recommendations concern the desirability of training crews for action in the events of such "unpremeditated crashes," and the subject of emergency exits in aircraft. Constellations, it states, should be equipped as a matter of urgency with at least two more emergency exits at the after end of the fuselage.

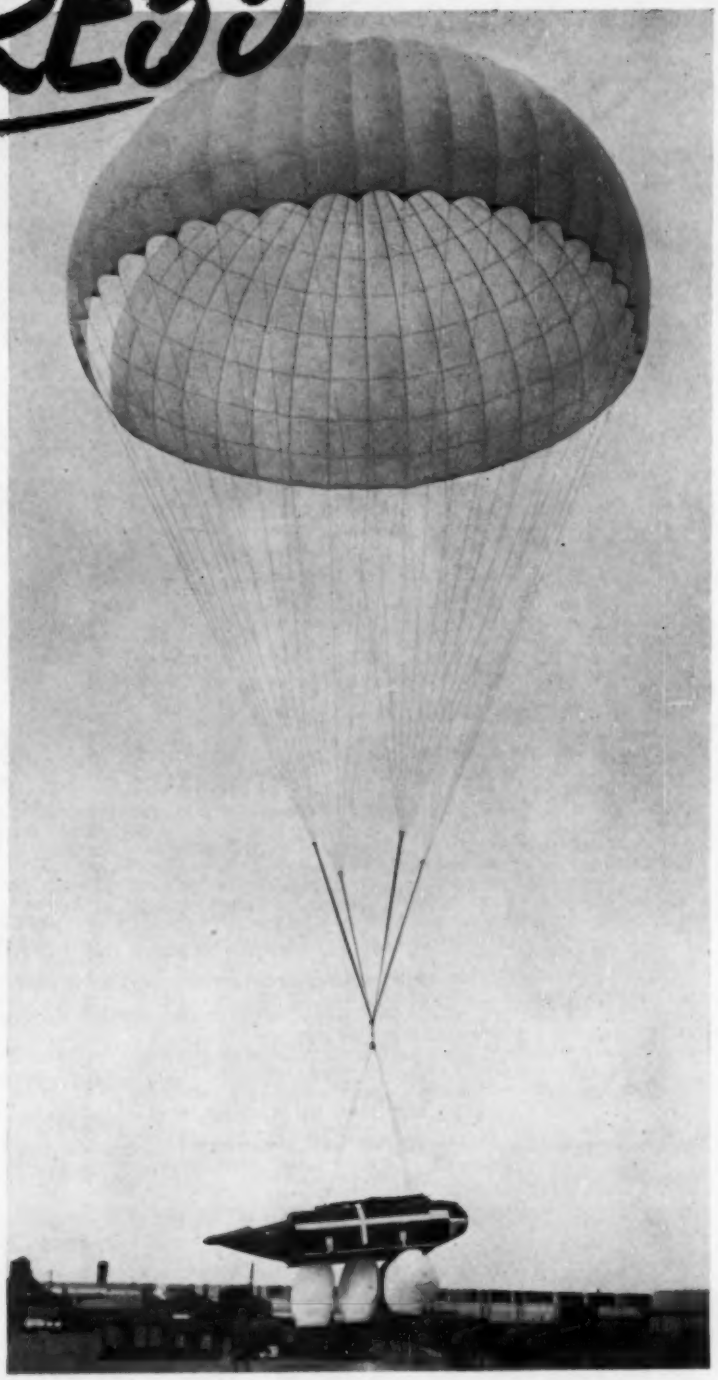
The report provides much food for thought on the part of airport authorities in many parts of the world. In many of the less developed countries, adequate fire services at airports are the exception rather than the rule, and the accident concerned might well have had a similar result at many places other than Kallang. One witness at the Kallang inquiry contended that "What really matters is a good and long runway on which pilots if necessary can make mistakes. It is this upon which money should be spent rather than on a fire service which does little but polish its brass equipment." There is little to be said for such a view; this is not, in our opinion, a matter for compromise. An airfield should not be licensed for aircraft operations unless both its runways *and* its fire services are adequate.

**Col. No. 312. Published for the Colonial Office by Her Majesty's Stationery Office at 6s.*

ATLANTIC NAVAIDS

THE third North Atlantic Regional Air Navigation meeting of I.C.A.O., which concluded its sessions recently in Montreal, has recommended the installation of Consol radio beacons in Iceland, South Greenland, Azores, Eastern Newfoundland, Labrador, Nantucket Island and Atlantic City. Together with the existing Consol stations in Europe, these new beacons should

PROGRESS



*

Used to accelerate take off of modern jet bombers, the de Havilland Super Sprite rocket motor is jettisoned after use.

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Bees and Bats

EVERY NOW AND AGAIN, said the Managing Director, someone gets a bee in his bonnet. He wants to put a nut where no nut was ever put before, or drill a hole round umpteen corners in a place only a bow-legged dwarf could reach. What, my friends is the result? Production lines go haywire and foremen go berserk. Should we then send such a person to Coventry? Not so. We should send him instead to the Desoutter Works, where members of my loyal staff are lined up waiting to give him what he deserves—some entirely new small power tool which puts his idea into practice at positively no trouble to anyone.

This service, which we are happy to provide for those with bees in the bonnet, does NOT apply to those with bats in the belfry.

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CDC 264

This Rapide, one of nine on the East African civil register, is used on the twice-weekly service from Entebbe round Lake Victoria by Caspair, Ltd.

"Flight" photograph

CIVIL AVIATION . . .

provide a complete long-range navigation chain for the North Atlantic, enabling aircraft to report their positions with accuracy and regularity.

The meeting made a general recommendation that, until these new facilities are provided, a minimum separation of 30 minutes' flying time should be maintained by two aircraft on identical or converging tracks, and that a minimum lateral separation should be kept between aircraft on parallel tracks of 120 nautical miles.

The decision to install the beacons was taken in view of the fact that existing Atlantic aids, while sufficient for safe navigation, do not permit of precise fixes at all times: wide separation between aircraft flying at the same levels is therefore required. Traffic over the Atlantic has increased greatly (the number of crossings in 1954 is expected to exceed 60,000, and this total should increase by 50 per cent over the next five years) and the need for separation causes inevitable delays to aircraft waiting to take off.

Another problem noted at the meeting was the high density in the Gander terminal control area, making it difficult for overflying aircraft to attain their desired flight levels. In order to facilitate the diversion of flights in the Gander area, it was suggested that Canada might consider the installation of a number of visual omni-ranges. Installation of V.O.R. on the Canadian portions of the routes between New York and Gander, New York and Goose Bay and Montreal and Gander was also suggested.

SKYWAYS ANNIVERSARY

SUCCESSFUL completion of twelve months' operation on their "Crusader" service to Cyprus was celebrated in London on November 10th by Skyways, Ltd. It was announced at an anniversary luncheon that the company intended to apply soon to the A.T.A.C. for an increase in the frequency of the service, which is at present operated fortnightly in each direction with Avro Yorks.

Regularity of the service during the last twelve months has been 100 per cent and, say the company, its punctuality has earned a high reputation. During recent months, they add, the average passenger load-factor has been 95 per cent; there were long waiting lists for practically every flight between March and October.

The key to the popularity of the service is, of course, the low fare charged—£75 return compared with a normal tourist return fare of £108, and a first-class return fare of £144. Flights leave Stansted for Cyprus on alternate Wednesdays, calling at Malta *en route* and arriving early next morning at Nicosia.

BREVITIES

EAGLE Aviation completed, on October 30th, a six-month airlift which enabled Servicemen from the Canal Zone to take their leave in the more temperate climate of Cyprus. Throughout the operation, Eagle kept four or five 36-seat Vikings permanently based at Nicosia, and these aircraft made over 500 round trips, carrying more than 16,000 men to and from their leaves.

* * *

All Soviet interests in Hungary, including Russia's shares in Maszovlet, the Hungarian state airline, are being sold to Hungary under an agreement signed in Moscow on November 6th.

* * *

More than 40 Hiller helicopters have now been sold to countries in South-East Asia. The latest customer is Philippine Air Lines, whose acquisition of a three-seat 12B brings the strength of their Hiller fleet to five.

* * *

An unofficial airline record for the Mexico City to New York route was set up on November 10th by a Super Constellation of Air France which covered the 2,100 miles in 6 hr 16 min—an average speed of 296 m.p.h.

* * *

The Minister of Transport and Civil Aviation has announced that General Sir Roy Bucher, K.B.E., C.B., M.C. (Indian Army retd.), has accepted his invitation to be chairman of the Transport Users Consultative Committee for the Yorkshire Area.

* * *

Capt. A. Vernieuwe, operations manager and chief helicopter pilot of Sabena, acted as chairman at a meeting of airline helicopter specialists convened by I.A.T.A. in Montreal last week. The chief subject for discussion was the operation of scheduled helicopter services.

* * *

To assist the Meteorological Office in further investigations of airframe icing, civil crews are asked (in *Information Circular No. 147*) to report on the occurrence or non-occurrence of icing in cloud at temperatures of 0 deg C. or lower. Icing report-forms will be available at airport meteorological offices.

* * *

The facility, previously available to B.E.A., B.O.A.C., and foreign airlines, of selling currency coupons to passengers to cover purchases at transit stops, has recently been granted by the Bank of England to Airwork, Ltd. The coupons are exchangeable for local currency abroad up to a value of 10s for a short stop and 30s for an overnight stop.

* * *

Machinery, vehicle parts and electrical equipment make up nearly a third of B.O.A.C.'s eastbound loads on cargo services from the United States. The second group of goods, according to a recent survey, comprises scientific, professional and precision instruments, apparatus and supplies, which make up 19 per cent of the Corporation's U.S. freight traffic.

* * *

Lufthansa has received permission from the Allied High Commission to import its four Convair 340s from America and to use the aircraft for training purposes only. The date for the start of scheduled services with the Convairs (initially, it is reported, from Hamburg to London, Paris, Zurich and Madrid) is now given as April 1955; four Super Constellations for the German transatlantic service are due for delivery at about this time.

Another East African scene—from the new airport at Dar-es-Salaam—shows a Sabena DC-4, a Noon and Pearce Bonanza and, taxying, a photographic Anson of Hunting Aerosurveys.

"Flight" photograph

SERVICE AVIATION

Royal Air Force and Fleet Air Arm News

Britannia Shield

PARTICIPATING for the first time since 1951, the French Air Force sent a strong team of athletes this year to compete for the Britannia Shield, which they won by 1½ points from Holland. The final placings were: 1st, France, 72½ points; 2nd, Holland, 71; 3rd, Great Britain, 68; 4th, Belgium, 56; 5th, Norway, 48; 6th, United States, 44½; 7th, Canada, 29.

In the fencing, France and Belgium tied for first place and in the swimming events Holland were the winners, with Britain a close second. Norway, by eight points, won the shooting events from Holland in very bad weather at Bisley. In the presence of the Duke of Edinburgh and members of the Air Council the R.A.F. team romped home to victory in the boxing events, losing only in the bantamweight class to France, who came second in the series of matches.

Far East Air Defence

AT a Press conference in Singapore, given by Air Marshal Sir Clifford Sanderson on the occasion of his handing over command of F.E.A.F. to Air Marshal Fressanges, it was stated that, in the event of Malaya being attacked, British air defence could be doubled in three or four days. It was also said that in an emergency British jet bombers could pour into the network of new and strengthened airfields in the Far East; that Malaya's potential air strength is now greater than ever before; and that co-operation between the R.A.F. in Malaya and the U.S.A.F. in the Phillippines had recently been considerably strengthened.

Air Marshal F. J. Fressanges, who now becomes C-in-C. Far East Air Force, was formerly Assistant C.A.S. (Intelligence).

New A.O.C. Malaya

WITH effect from February next, A. Cdre. W. H. Kyle, C.B., C.B.E., D.S.O., D.F.C., A.D.C., is to become A.O.C. Malaya. He will assume the acting rank of Air Vice-Marshal.

A. Cdre. Kyle has been Director of Operational Requirements (A) since 1952, and before that was Assistant Commandant at R.A.F. College Cranwell.

Operational commands he held during the war include that of No. 139 (Bomber) Squadron, and it was while serving with this unit that he was awarded the D.F.C. for leading the attack on the Ijmuiden steel works in 1941. He commanded both Horsham St. Faith—where the first Mosquito day bomber squadron was formed—and Marham. Later he became an air staff officer at Bomber Command. He was awarded the D.S.O. in 1945.

A. Cdre. Stephenson

WITH regret we record the death of A. Cdre. G. D. Stephenson, C.B.E., as the result of an accident while flying a North American F-100 Super Sabre in the United States. Reports say that while he was about to join formation at 15,000ft with Capt. Moore, U.S.A.F., on a similar aircraft, he went into a "deep spiral" from which he did not recover.

Commandant of the Central Fighter Establishment at West Raynham, Norfolk, A. Cdre. Stephenson was in America at the head of a team of officers touring that country to study defence problems, fighter requirements and operational procedures. He was buried with full military honours at Montgomery, Alabama.

A. Cdre. Stephenson passed out from Cranwell in 1930 and became an instructor at C.F.S.—to which famous school he returned in command during the years 1948-50. During the early part of the war he served with No. 19 (Fighter) Squadron and in 1940 was shot down over Dunkirk, remaining a prisoner of war until the end of hostilities.

Taranto Dinner in "Illustrious"

ON Friday evening last the Fleet Air Arm annual dinner to celebrate the Naval air victory at Taranto in 1940 was held in H.M.S. *Illustrious* at Portsmouth. It was the first time the function had been held in a carrier, but the choice was singularly appropriate, because it was the Fairey Swordfish from *Illustrious* and *Eagle* that made the successful attack on the Italian Fleet. For the occasion a surviving Swordfish was brought from Lee-on-Solent was placed on the flight deck, where it was floodlit.

Capt. K. A. Short, who commands *Illustrious*, presided at the dinner, and the guests who had been present at Taranto included Admiral Sir Lumley Lyster, then Rear-Admiral Commanding Mediterranean Aircraft Carriers (in H.M.S. *Illustrious*); Admiral Sir Denis Boyd, in command of *Illustrious*; and Commodore C. L. G. Evans, who led the fighter attack.

No. 57 Squadron Home

THE six Canberras of No. 57 Squadron which left England on November 8th for a 7,600-mile training flight to the Middle East were to have returned to their base at Cottesmore on Sunday last, but an extra day was spent at Idris.

During the trip they gave a flying display at Baghdad on November 6th to coincide with the end of the British Trade Fair held in the city. This display was watched by the Crown Prince of Iraq, H.R.H. Prince Abdul Illah, who was in R.A.F. uniform as an Honorary Air Vice-Marshal. He was taken for a short flight, at his own request, by S/L. I. G. Broom, D.S.O., who commands No. 57 Squadron. The British Ambassador, Sir John Troutbeck, also flew in a Canberra, piloted by F/L. U. L. Burberry.

In co-operation with units of the Iraqi Army, on November 9th the Canberras carried out a target-location exercise, and later paid their compliments to the Royal Iraqi Air Force by flying in formation over the air base at Kirkuk.

On November 10th they gave a display at Amman, where King Hussein, who is himself a pilot, also flew with S/L. Broom, thus becoming the first reigning monarch to fly in a jet bomber. While the King and other dignitaries were making their flights No. 249 Squadron gave formation and individual aerobatic displays with their Vampires.

"The Lost Generation"

WORLD performing rights of the new play "The Lost Generation" have been presented to the R.A.F. Benevolent Fund by the author, Patricia Hollender.

The play, which was due to open at the New Lindsey Theatre, Notting Hill Gate, London, last Tuesday, deals in part with the Battle of Britain and includes recordings made in air raid shelters and on roofs during the actual battle. The cast includes Mary Hinton and Valerie White. Air Chief Marshal Lord Dowding accepted an invitation to attend on the first night.

During the war, Miss Hollender and her sister both served as V.A.D. nurses in plastic surgery at the East Grinstead hospital and her father, Count Vivian Hollender, serving in his third war, became a pilot officer at the age of 63 and was mentioned in despatches.

New Zealand Army Airlift

TO ensure that 500 New Zealanders travelling from Korea will be home by Christmas, airlift arrangements have been made to pick them up from Brisbane and Sydney, where they will arrive by ship from Pusan. The flying will be divided between Tasman Empire Airways and the Royal New Zealand Air Force.

Malayan Awards

BELOW is concluded the list of awards recently announced for service in Malayan operations. The details concerning the awards are taken from the official citations:—

D.F.M.

Sgt. C. Fenwick, who has completed nearly 2½ years with No. 48 Squadron, with whom he has flown over 1,810 hours, of which 407 hours in 168 sorties were flown in direct support of the ground security forces in Malaya. Since the middle of September 1951 he has flown 202 hours on 77 sorties in this rôle.

Cpl. A. G. Gilbert, R.A.S.C., who has been employed since November 1951 with No. 55 Company R.A.S.C. (Air Despatch) in Malaya. Since this date, he has flown 179 operational supply dropping sorties as an Army Despatcher with the Transport Squadrons of the Far East Air Force. This figure amounts to a total of some 500 hours.

S/Sgt. J. I. Ford, No. 656 (A.O.P./L.L.) Squadron; who has been a pilot of the squadron for over two and a half years. He has shown the highest qualities as an N.C.O. and a light aircraft pilot. He has flown a large number of

The Duke of Edinburgh attended the final events of the Britannia Shield competition at the Empire Pool, Wembley, and presented the trophy to Commandant Devign, on behalf of the winning French team.

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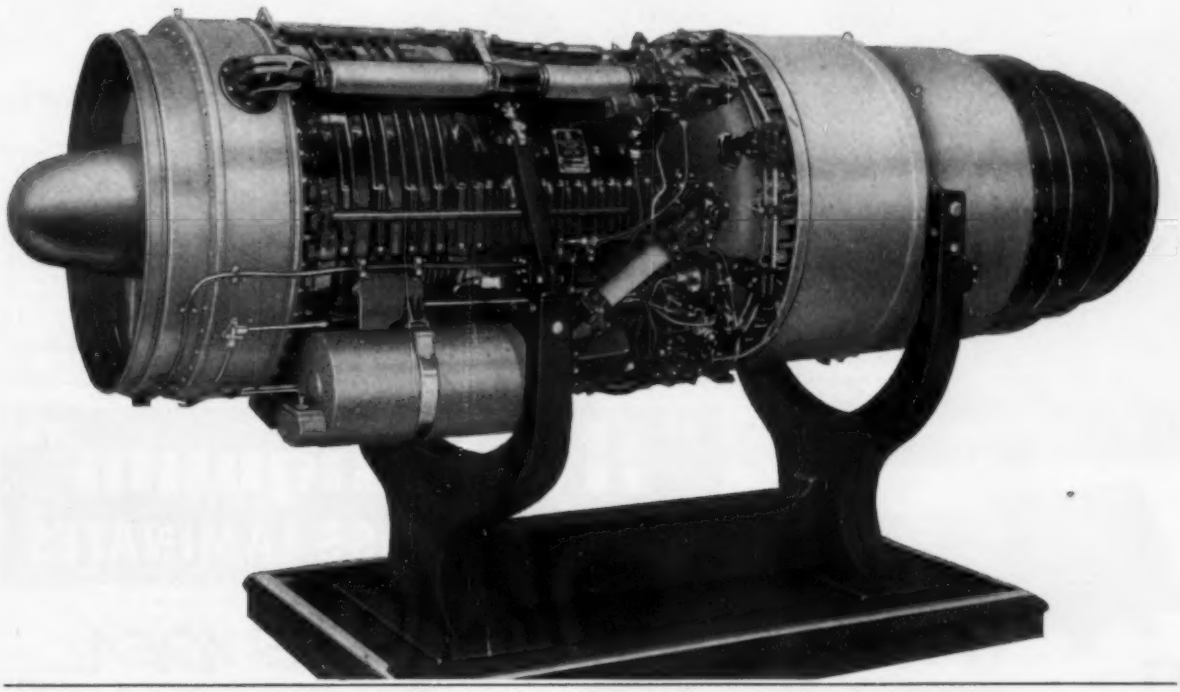

The "Avon" engine is in large scale production in several versions as the power plant for many types of bombers, fighters, and civil aircraft. It is an axial-flow turbo-jet which has steadily been developed since its inception to give thrust ratings well into five figures. Versions have been installed in the De Havilland "Comet" II and III, English Electric "Canberra", Supermarine "Swift", Hawker "Hunter" and Vickers "Valiant". As in all British aircraft gas turbines, Nimonic Alloys are employed in the "Avon" to combat creep, fatigue and high-temperature oxidation.

Nimonic Alloys are used for the moving blades and other components of all British aircraft gas turbines.

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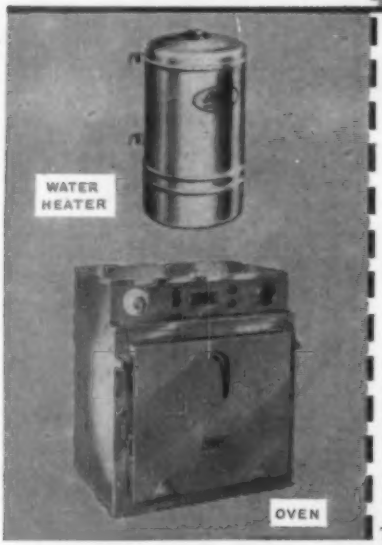

. . . IN THE B.O.A.C. BRITANNIA

B.O.A.C. sets a high standard of passenger comfort and serves excellent meals in its aircraft.

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2 *Trimmed and drilled component.*
3 *"Hy-du-lignum" support frame.*

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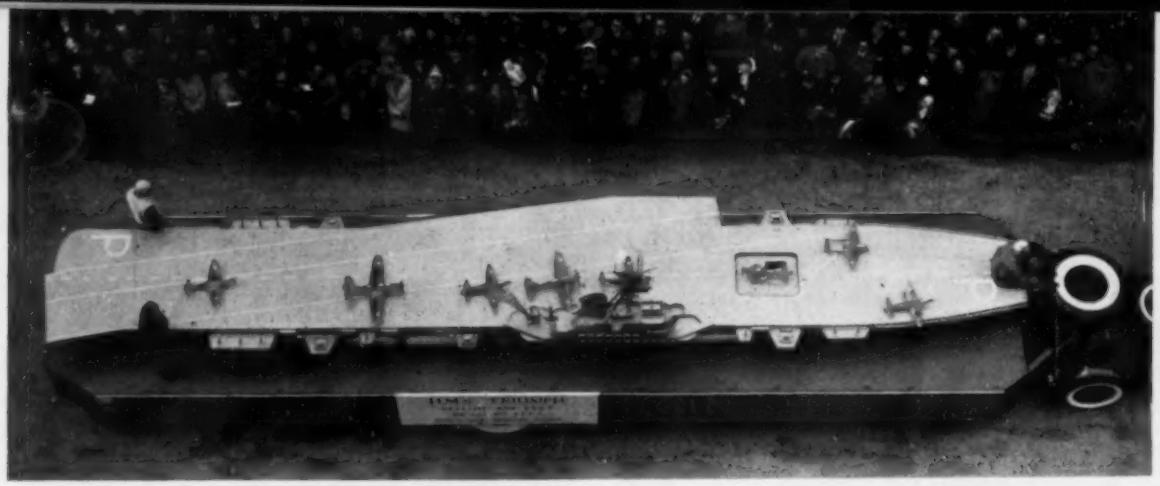

In London last week the R.A.F. and the Fleet Air Arm both had impressive displays in the Lord Mayor's Procession. (Above) H.M.S. "Triumph"—as she might appear after a very extensive refit. (Right) The R.A.F. Canberra tableau, while passing the Mansion House, is watched by medieval-uniformed coachmen.

SERVICE AVIATION . . .

hours in support of emergency operations in Malaya, frequently over dense jungle far from habitation.

B.E.M.

Sgt. D. A. Howard. During the past year Sgt. Howard has been at Kuala Lumpur in charge of the servicing detachment for Valetta aircraft. By force of character, energy and devotion to his work, he has achieved exceptional results and the record for supply drops has twice been broken during his period of leadership.

Act.-Sgt. B. bin Bakir, who is senior airman in the R.A.F. (Malaya) and has been the personal driver of eight successive Air Officers Commanding and Commanders-in-Chief since 1935, when the then A. Cdre. Tedder was in command at Seletar. He is a driver of exceptional quality and has an accident-free record for the twenty years he has been driving in the Royal Air Force.

Cpl. D. N. Gibson, No. 656 (A.O.P./L.L.) Squadron, who has been an engine fitter with 1902 (A.O.P.) Flight, Sembawang for 16 months. He has displayed outstanding technical ability. He has frequently gone out with the Flight on detachment and maintained aircraft under the most adverse conditions. He has worked through all hours of the day and night when necessary to make aircraft serviceable.

Cpl. Tech. H. F. Cobb, who has served at Changi for 2½ years on second line servicing of Hercules engines in Valetta aircraft and has shown extreme devotion to duty. On 25 occasions he has at extremely short notice been sent to various staging posts on the routes covered by Far East Transport Wing and to Kuala Lumpur to rectify unserviceable aircraft.

Mention in Despatches

Squadron Leaders: P. R. Little, R.A.F. Regiment, A. D. Miller, A.F.R.Ae.S., H. W. Busen-Schmitz, A.M.I.Mech.E., A.F.R.Ae.S. Flight Lieutenants: F. W. G. Adams, D. A. Caris, D. Fish, E. P. Ledlie, W. Macleod, D.F.M., J. A. B. Pemberton and A. R. Stewart, M.B.E. Flying Officer: J. E. A. Parker. Warrant Officers: W. G. Perkins, P. Pratt and L. C. Tite.

Flight Sergeants: G. W. Bennington, L. Bryce, A. F. Craighill, E. Dempsey, J. McK. Robertson, W. D. Rooke, R. Sinfield and F. H. Smith. Sergeants: S. T. Clifton, P. G. Drabble, J. D. Land, M. A. bin Haji Ghani, R.A.F.(Malaya), C. E. Sloper and B. R. Woods. Act.-Sergeant: H. J. Wright. Corporals: F. Cross, R. P. Millyard, L. B. Richardson, J. Teasdale and J. W. Wood. Senior Aircraftsmen: B. Parker and I. Slade.

No. 77 Squadron Returns Home

AT the end of last month the Australian aircraft carrier H.M.A.S. *Vengeance* left Sydney for Japan to bring No. 77 Squadron R.A.A.F. back to Australia.

This squadron entered the fighting in Korea very shortly after the war broke out and claims to hold the record for the number of sorties flown against the enemy.

Nearly 300 National Service Naval trainees are on board *Vengeance*, making the trip to Japan as part of their training.

Thirty-seven Years Overseas

ORIGINALLY formed as No. 16 Squadron, R.N.A.S., at Manston in October, 1917, and redesignated No. 216 when the R.A.F. came into being on April 1st, 1918, No. 216 Squadron recently celebrated its 37th overseas birthday.

To mark the occasion a dinner was recently held in Fayid Olympia, Suez Canal zone. Presiding was the present commanding officer, S/L. W. J. Swift, and the guests included A.V-M. D. H. F. Barnett, A.O.C. No. 205 Group, G/C. D. Finlay, Officer Commanding R.A.F. Fayid, and a number of past members of the squadron at present serving in the Middle East.

Twelve days after forming, the squadron moved to France, where it was the first to carry out night-bombing attacks on Cologne and Mannheim; and in July 1919 it was transferred from France to Egypt, where it has been based ever since.

In the Second World War the squadron blazed the West African supply route to the Middle East and took part in the Greece and Crete campaigns and in the advance across the Western Desert to Tunis and on to Sicily and Italy.

No. 800 Squadron Formed

EQUIPPED with 12 Hawker F.B.3 Sea Hawks, No. 800 Squadron, R.N., was commissioned at R.N.A.S. Brawdy, Pembrokeshire, on November 8th. In command is Lt-Cdr. R. D. Lygo, R.N.

R.Aux.A.F. Appointment

WITH effect from the beginning of this month S/L. W. G. Abel has been appointed to command No. 616 (South Yorkshire) Squadron, R.Aux.A.F.

S/L. Abel joined the R.A.F. in 1941 and during the war served in Canada and Great Britain. At the end of hostilities in Europe, he went to the Far East. For the past two years he has been squadron commander at No. 202 Advanced Flying School.

No. 88 Squadron Tie

ALTHOUGH the unit was recently disbanded, No. 88 Squadron ties are now available to ex-members. They are obtainable from T. M. Lewin and Sons, Ltd., 103, Jermyn Street, London, S.W.1, at 19s. 6d.

THE INDUSTRY

Warrington Inauguration

AT Warrington on November 4th, Mr. A. G. B. Owen, C.B.E. (chairman of the Owen Organization and vice-chairman of Electro-Hydraulics, Ltd.), together with his brother, Mr. E. W. B. Owen (joint managing director of Rubery Owen and Co., Ltd., and a director of Electro-Hydraulics, Ltd.), laid the foundation stones of the latter company's new research laboratories. Among those present at the ceremony were Mr. F. S. Mitman, C.B.E., chairman of Electro-Hydraulics, and Mr. C. W. Sharp, managing director. The latter commemorated the event by presenting the ceremonial mallet to Mr. Mitman and silver trowels to Messrs. A. G. B. and E. W. B. Owen. Other directors in attendance were Mr. R. J. Norton, Mr. C. B. V. Neilson (technical) and Mr. L. R. Rumley (sales).

Well known as specialist designers of undercarriages and hydraulic equipment, the company conducts research work on a considerable scale. In two wings, and with space for expansion, the laboratories will accommodate the whole of the design and technical research departments and are to be equipped with the most modern testing and research apparatus available, including the latest types of drop-test machines.

Electro-Hydraulics' new laboratories (see first news item): Mr. E. W. B. Owen declares one of the foundation stones well and truly laid. He is watched by Mr. C. W. Sharp (managing director), Mr. F. S. Mitman (chairman) and Mr. C. D. McIntosh, the architect.

Export Acquisition

ON November 1st, the General and Overseas Trading Corporation, Ltd., took under their control the entire export sales in world markets of Alumilite and Alzak, Ltd., specialists in anodizing, chemical oxydation, and decoration of aluminium and aluminium alloys; the company holds M.o.S., A.I.D., A.R.B., and A.N.R. approval. Also handled by GOTAC are the products of Rainville Engineering Co., Ltd., manufacturers of "Beryl" fractional horse-power motors; Saturn Industrial Gases, Ltd.; Gospo, Ltd.; Merton Metalcraft, Ltd.; and Metal Chemical Treatments, Ltd.

Although GOTAC have been established as import and export traders in general merchandize for some years, they have recently extended their field to include products of the aeronautical industry. They now have an aeronautical division which is concerned with sale and purchase of aircraft products for all types of aircraft equipment for firms and for foreign governments.

GOTAC's chairman, Mr. F. Elles-Hill, F.C.A., and Mr. T. O. M. Pope, are chairman and director respectively of an associate company, Eastova, Ltd., which has trading interests in Turkey and the Middle East. The parent organization's offices are now housed at Downshire House, Roehampton Lane, London, S.W.15 (Putney 7744).

Easy Cleaning

AN easy method of cleaning both the exterior and interior of aircraft is suggested by Lexington Products, Ltd. (2 Lexington Street, London, W.1)—i.e., use of the "Nenette" dust-absorbing polisher. In outward appearance the polisher resembles a small hand-mop, but its efficiency as a dirt remover depends on the fact that it is impregnated with a solution of "Nenetol," which retains the particles of dust and dirt picked up. No matter how much the mop is shaken after use, no dust is released. After 6-9 months it can be washed and re-impregnated.

As a secondary function, Nenetol is a polish; thus the mop will clean away dirt and at the same time impart a gloss. We ourselves have used these mops on cars and have found them to fulfil the makers' claims; also, they can be used effectively on chromium and glass as well as on paintwork.

IN BRIEF

Hellermann, Ltd., announce the appointment of Mr. T. T. Conlon as sales manager. Sales policy will continue under the direction of Mr. Norman L. Keen.

* * *

Known as "Poly-FBA," a new synthetic rubber in experimental production in America can, it is stated, withstand boiling in oil. Its characteristics were recently described to the American Chemical Society in a paper by two research chemists of the Minnesota Mining and Manufacturing Co., Ltd., St. Paul, Minn.

* * *

Viscount Weir of Eastwood, making one of his now rare public appearances, took the chair at a recent luncheon to celebrate the 25th anniversary of the founding at Glasgow of the Zenith Works of Henry Wiggin and Co., Ltd. The works will be remembered in connection with the original introduction into this country of the nickel-copper alloy known as Monel; it was Lord Weir who obtained from Canada the concession for Great Britain.

This "Eascolyte" water-activated floatable raft-light is automatic in action, the sealing-strip being torn away by the lanyard when the raft is launched. The efficiency of the battery, it is stated, does not deteriorate in storage. The particular type illustrated here is designed for shipboard use, but the makers (Easco Electrical, Ltd., Brighton Terrace, London, S.W.9) are investigating the possibilities of a similar, but lighter, device for aircraft dinghies.

Shaw Processes, Ltd., of 25 Clyde Vale, Dartmouth Road, Forest Hill, S.E.23, proprietors of the Shaw process of precision casting, have now extended their activities to Australia, where a company has been formed, in association with Vericast, Ltd., under the title of Shaw Processes (Australia) Pty., Ltd., Victoria. Directors are Mr. Clifford Shaw, Mr. Noel Shaw, Col. Peter Chance (chairman), and Mr. Kenneth Spencer.

* * *

The firm of Petbow, Ltd., Sandwich, Kent, perhaps best known in the aircraft industry for their ground starter units, have issued a very handsome loose-leaf catalogue which shows the very much wider scope of their activities. Equipment described and illustrated includes engine- and mains-operated welding equipment, electrodes and accessories, stationary and mobile generators, mobile service units (workshop, surgical, laundry, etc.), road-traffic signal equipment, and air compressors.

* * *

Mr. K. A. Maclean, B.Sc. (Eng.), A.M.I.Mech.E., until recently assistant to the general works manager of the Northern Aluminium Co., Ltd., has been appointed head of the fabricating division of Aluminium Laboratories, Ltd., Banbury. The latter company states that he will operate in support of the interests of Aluminium, Ltd., in the territories for which Aluminium Laboratories, Ltd., Banbury, is responsible—Europe, Africa, and India—and will work in collaboration with an equivalent division at Aluminium Laboratories, Ltd., Kingston, Ontario.

* * *

A new interior lighting system announced by Lumenated Ceilings, Ltd., 4 Lloyd's Avenue, London, E.C.3, consists of a ceiling of corrugated translucent vinyl sheet, supported in a framework of lightweight steel, suspended below fluorescent or tungsten lamps. The sheet diffuses the light to form an evenly, softly luminous ceiling, although the intensity may be as low as 20 lumen/sq ft or as high as 200. These ceilings—which can be installed, from standard assembly parts, in existing buildings—are claimed to be the nearest approach to natural daylight yet devised in any lighting system.

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FROM Hunting-Clan Air Transport Ltd., of 5 Fitzhardinge Street, London, W.1.:—

APPLICATION No. 407. For a Seasonal Inclusive Tour Service with Dakota and Viking aircraft, in conjunction with The Workers Travel Association, Ltd., for the carriage of passengers between London Airport and Venice (Treviso) at a frequency of 11 services during the season from July to September inclusive, each year, for a period of five years, commencing July, 1955.

APPLICATION No. 408. For a Seasonal Inclusive Tour Service with Dakota and Viking aircraft, in conjunction with The Workers Travel Association, Ltd., for the carriage of passengers between London Airport and Bilbao at a frequency of 11 services during the season from July to September inclusive, each year, for a period of five years, commencing July, 1955.

APPLICATION No. 413. For a Seasonal Inclusive Tour Service with Dakota and Viking aircraft, in conjunction with the Wayfarers Travel Agency Ltd. for the Holiday Fellowship Ltd. and The Co-operative Holiday Association, for the carriage of passengers between London Airport and Munich at a frequency of eight services during the season from May to September inclusive, each year, for a period of five years, commencing May, 1955.

APPLICATION No. 414. For a Seasonal Inclusive Tour Service with Dakota and Viking aircraft, in conjunction with the Wayfarers Travel Agency Ltd. for the Holiday Fellowship Ltd. and The Co-operative Holiday Association, for the carriage of passengers between London Airport and Basle at a frequency of seven services during the season from June to August inclusive, each year, for a period of five years, commencing June, 1955.

FROM Silver City Airways, Ltd., of 1 Great Cumberland Place, London, W.1.:—

APPLICATION No. 409. For a Vehicle Ferry Service with Bristol 170 aircraft, for the carriage of vehicles, passengers and supplementary freight between Belfast (Newtownards) and Stranraer (West Freugh) at a frequency of up to 12 services daily increasing according to traffic demand for a period of 10 years commencing at or before Easter, 1955.

APPLICATION No. 410. For all Freight and Vehicle Ferry Services with Bristol 170 aircraft for the carriage of vehicles, passengers and freight as appropriate to the service between London (Blackbushe) and Belfast (Newtownards) with intermediate traffic stops at Birmingham (Elmdon) and Formby (Wood Vale) at a frequency of from one to two services daily for a period of 10 years, commencing at or before Easter, 1955.

APPLICATION No. 411. From Cambrian Air Services, Ltd., of Cardiff Airport, Nr. Barry, Glam., for a Seasonal Normal Scheduled Service with Dakota aircraft for the carriage of passengers, supplementary freight and mail between Cardiff (Rhoose) and/or Bristol (Whitchurch) and/or Southampton (Eastleigh) and Nice (Le Var) at a frequency of two services weekly, increasing according to traffic demand, during the season from May to September inclusive, each year, for a period of 10 years, commencing 1st May, 1955.

APPLICATION No. 151/1. From Aquila Airways, Ltd., of 1 Great Cumberland Place, London, W.1, for permission, on the Normal Scheduled Services which they are approved by the Minister of Transport and Civil Aviation to operate during the period until 31st December, 1955, on the routes Southampton-Lisbon-Madeira, Madeira-Las Palmas, and Madeira-Lisbon, to operate also according to traffic requirements between Southampton and Las Palmas either direct or by way of a traffic stop at Lisbon, alternative to that at Madeira.

APPLICATION No. 415. From Lancashire Aircraft Corporation, Ltd., of 7 Berkeley Street, London, W.1, for a Seasonal Inclusive Tour Service with Dakota aircraft in conjunction with See Spain, Ltd., for the carriage of passengers and supplementary freight between London (Gatwick) and Perpignan at a frequency of up to three services weekly during the season from the first Monday in June to the third Monday in September inclusive, each year, for a period of 10 years, commencing 6th June, 1955.

THESE applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on 30th July, 1952. Any representations or objections with regard to these applications must be made in writing, stating the reasons, and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3 Dean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections.

THE Air Transport Advisory Council also give notice that the following application has now been withdrawn:—

APPLICATION No. 354 from Cambrian Air Services, Ltd., of Cardiff Airport, Barry, Glam. for a Seasonal Normal Scheduled Service between Guernsey and Dinard, with D.H. Dove and D.H.89 aircraft, which was advertised in "The Times" and "Flight" on September 10th, 1954, and in "The Aeroplane" on September 17th, 1954. [2896

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PATENTS

THE proprietors of British Patent No. 628,324 for "Retractable Landing Gear for Aircraft," desire to enter into negotiations with a firm or firms for the sale of the patent, or for the grant of licences thereunder. Further particulars may be obtained from Marks & Clerk, 57 & 58, Lincoln's Inn Fields, London W.C.2. [2871

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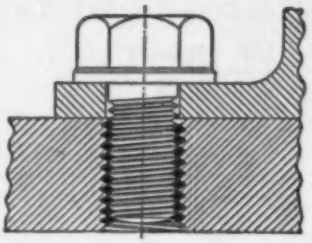

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FIRST-CLASS mechanical design draughtsmen are required for interesting and important projects.—Please write in detail or send postcard for application form to The Personnel Manager (Technical Employment), de Havilland Propellers, Ltd., Hatfield, Herts. [0610

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THE Supermarine Works of Vickers-Armstrongs Ltd. require men with a degree, H.N.C. or an equivalent qualification for technical posts concerned with the development flight testing of fighter aircraft. Experience of similar work would be an advantage.—Write, giving full particulars, to Personnel Department, Vickers-Armstrongs Limited, Hursley Park, Nr. Winchester. [2818

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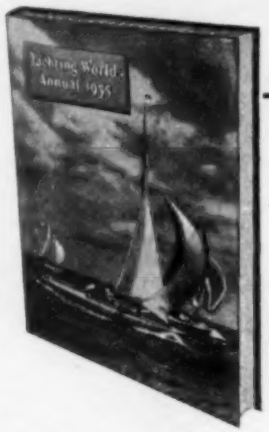

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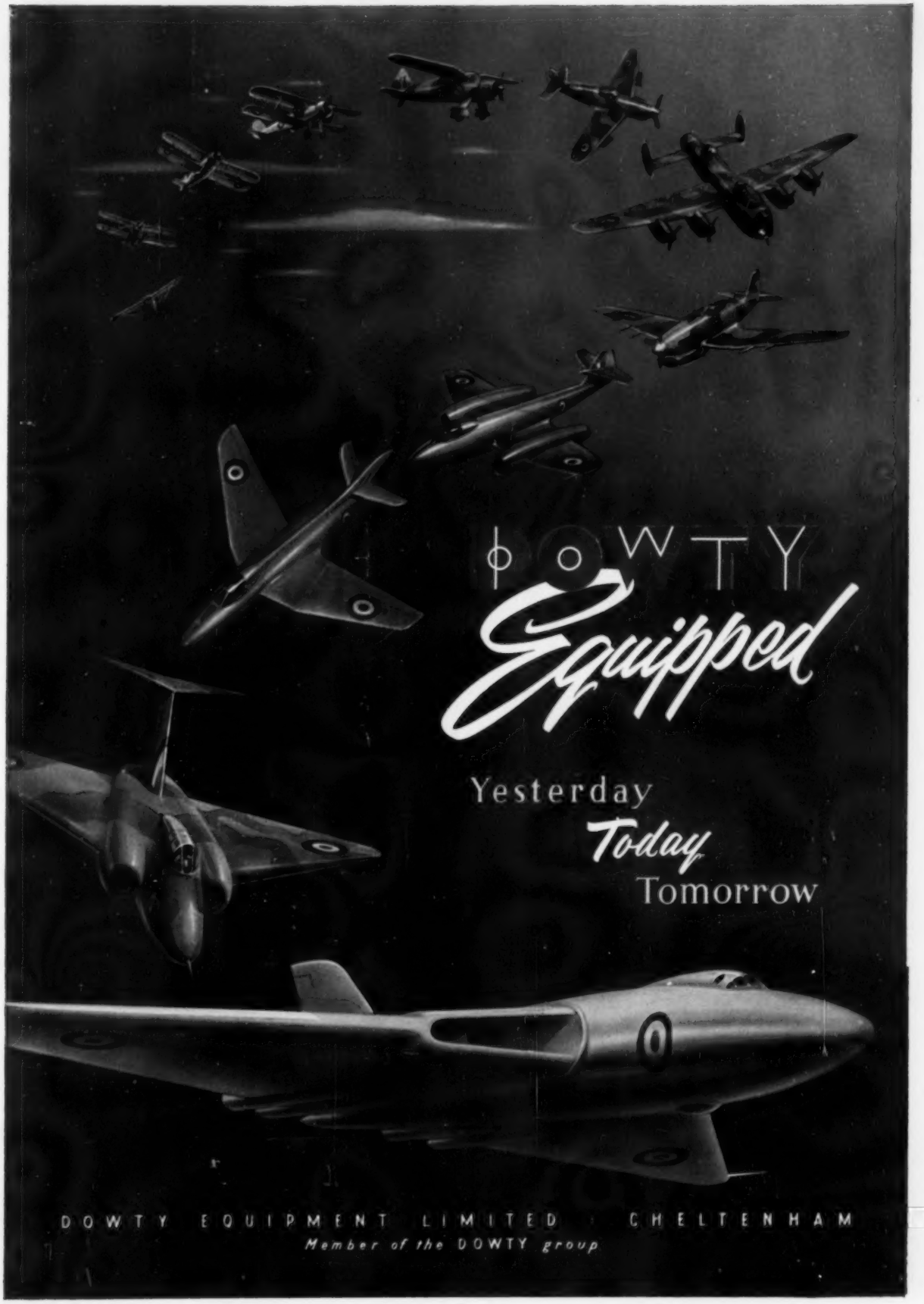
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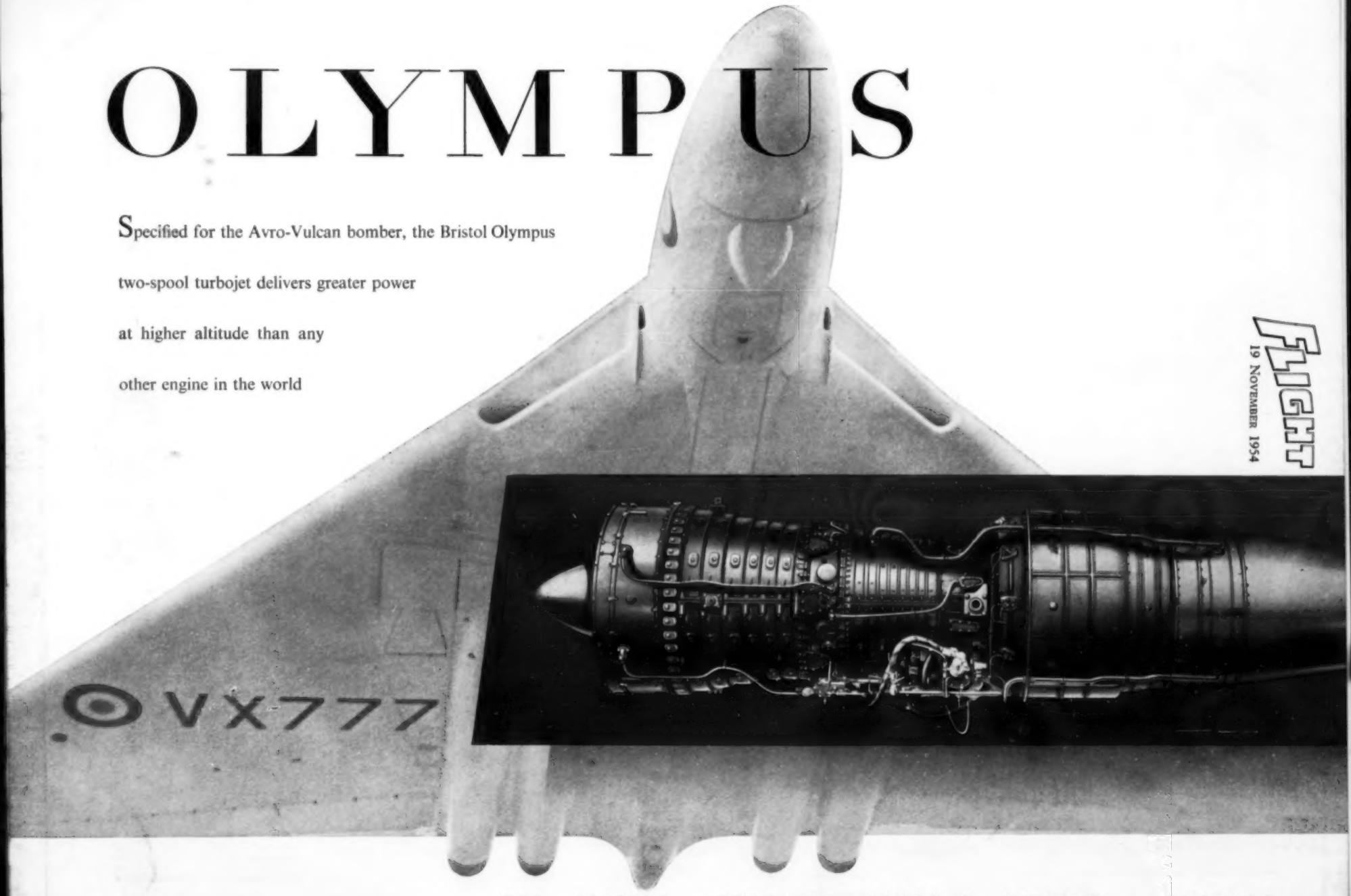

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